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ABSTRACT

This study, tenth in a series of publications entitled "Studies in the Phonology of Asian Language," describes the phonetic variation of the six tones in two-syllable utterances of Vietnamese. The study is based on acoustic measurements of actual words and phrases. Findings of the study concern: (1) overall pitch height of a tone, (2) tone variants and crossing in given syllable positions, (3) range of variation of tones, (4) differentiation of level tone from the falling tone, and (5) environmental influence on the six-tone contrast. (RL)

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STUDIES IN THE PHONOLOGY OF ASIAN LANGUAGES

X

INTERTONAL INFLUENCES IN TWO-SYLLABLE UTTERANCES OF VIETNAMESE

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Preface

This study, Intertonal Influences in Two-Syllable Utterances of Vietnamese, is the tenth publication in the series Studies in the Phonology of Asian Languages. It is the result of a research project sponsored by the Office of Naval Research and serves as a final technical report for the contract NR 049-183, N00014-67-A-0269-0016.

The following works have been published previously in the series:

Vol. 1 Korean Vowels
Vol. 2 Duration of Korean Vowels
Vol. 3 Acoustic Characteristics of Korean Stop Consonants
Vol. 4 Vietnamese Vowels
Vol. 5 Acoustic Features in the Manner Differentiation of Korean Stop Consonants
Vol. 6 Complex Syllable Nuclei in Vietnamese
Vol. 7 Korean Affricates
Vol. 8 Vietnamese Tones
Vol. 9 Word Accent in Japanese

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Los Angeles
June 1972

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INTERTONAL INFLUENCES IN TWO-SYLLABLE UTTERANCES OF VIETNAMESE

Introduction

The purpose of the present study is to describe the acoustic characteristics of the six tones in two-syllable utterances of Vietnamese. Our study is based on the acoustic measurements of actual words and phrases. We have decided to use actual words and phrases for the naturalness of the test utterances. There is also the assumption that we can control the factors influencing the fundamental frequency (hereafter abbreviated as f_0) of voicing in speech without affecting the naturalness. The following factors influence f_0 of an utterance:

1) The emotive state of the speaker greatly affects the f_0 of voicing in speech.

2) The intonation pattern exerts great influence on the f_0 of the individual syllables.

The above two factors can be controlled to a certain extent by giving proper instructions to the informant and also by carefully selecting the frame in which the informant records the test utterances.

3) There is an inherent f_0 difference between different vowels spoken by an individual speaker in a given condition, which is derived from the inherent physiological constraints associated with the production

of the vowels. Peterson and Barney[1] report 17 Hz difference between English /u/ and /a/ in the speech of a male speaker with an average of about 130 Hz voice fundamental. Lehiste and Peterson[2] report 20 Hz difference between English /i/ and /a/ in the speech of a male speaker with an average of 170 Hz voice fundamental. According to Han,[3] the difference is about 20 Hz between high vowels and other vowels of Vietnamese in the speech of a female speaker with an average of 280 Hz voice fundamental. A much smaller difference, 5 Hz, is observed by Ladefoged[4] in Itsekiri, an African tone language. All of these differences are between high vowels and non-high vowels. In both Lehiste and Peterson, 1961 and Han, 1969, the greatest difference between mid and low vowels is 8 Hz which is less than 5% of the voice fundamental.

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[1]G. E. Peterson and H. L. Barney, "Control Methods Used in a Study of the Vowels," JASA, Vol. 24, No. 2, 1951, pp. 175-185.

[2]I. Lehiste and G. E. Peterson, "Some Basic Considerations in the Analysis of Intonation," JASA, Vol. 33, No. 4, 1961, pp. 419-425.

[3]M. S. Han, Studies in the Phonology of Asian Languages VIII: Vietnamese Tones, Acoustic Phonetics Research Laboratory, University of Southern California, 1969.

[4]P. Ladefoged, "A Phonetic Study of Western African Languages: An Auditory-Instrumental Survey," Monograph Series No. 1, Cambridge University Press, 1964.

4) The influence of consonants on the f_o of syllable nucleus has been studied by House and Fairbanks[5] and Lehiste and Peterson (Lehiste and Peterson, 1961). Both groups report that different consonants affect the f_o of the following vowel within the same syllable to a different degree and that the difference in the degree of influence is attributed mainly to the voicedness and voicelessness of the consonants. Thus the f_o of a vowel after a voiced consonant is generally lower than that of the same vowel after a voiceless consonant. The average difference caused by these two groups of consonants is 8 Hz (4.5% of voice fundamental) and 4.5 Hz (1.5% of voice fundamental) according to Lehiste and Peterson, 1961 and House and Fairbanks, 1953, respectively. The difference in the degree of influence of different consonants among voiced or voiceless consonants on the f_o of the following vowel does not exceed those differences given above.

If we select the test utterances keeping the above influencing factors in mind, we can, to a certain extent, reduce the effect of these factors. Thus if we use those utterances which contain either only high vowels or non-high

[5]A. S. House and G. Fairbanks, "The Influence of Consonant Environment upon the Secondary Acoustical Characteristics of Vowels," JASA, Vol. 25, 1953, pp. 105-133.

vowels, then we can at least avoid the effect of the third factor in the above. Again if we use those utterances which contain either exclusively voiced consonants or voiceless consonants, then we can considerably reduce the consonantal effect on the f_o of the syllables. Even though the degree of the combining effect of the third and fourth factors above is not available in literature, we have observed that it is always much less than the sum of these two effects. We will describe in the following section how we selected the test utterances used in the present study.

Material and Method

For the purpose of obtaining a reference system of the six tone contrast, eighty-one one-syllable words were chosen, all of which are commonly used words in Vietnamese. These words have the syllable structure of CV or CVC, C's and V's being consonants and vowels respectively. Furthermore, all C's are voiced consonants except for a few voiceless stops in the final position of the words in rising and drop tones, and the syllable nucleus is the tense low central vowel /A/ in all eighty-one words. These test utterances were chosen with consideration of the factors influencing f_0 values of utterances as discussed in the preceding section.

For two-syllable test utterances, six to twenty-five words or phrases have been selected for each of the thirty-six combinations of the six tones in the sequence of two syllables with the exception of the combination of the broken + curve tones where it is very difficult to find actual words and phrases suitable for our analysis. Thus we use only two test utterances for this combination. Again, with the influencing factors in mind, we tried to select only those utterances which begin with voiced consonants and contain non-high vowels as the syllable nucleus. Among the 1,118 syllables of our entire corpus of two-syllable test utterances, approximately 7% contain high vowels, most-

ly /u/. We have only six occurrences of voiceless consonants in syllable initial position.

In syllable final position, only four voiceless consonants /p,t,k,č/ occur with rising and drop tones. We are aware of the unusual pitch contour and higher overall pitch level in syllables ending in these consonants. In most cases, the pitch contour of rising tone in such syllables lacks the first portion of gradual pitch rise as typically observed in the other type of syllables. The drop tone in the syllables with those final voiceless consonants lacks, in most cases, the laryngealization at the end. Sampson[6] regards these two types of phonetic tones as different from the rising and drop tones. However, in the present study we take these as variants of the rising and drop tones as Han (1969) does. We have included a considerable number of such syllables in our analysis due to the shortage of test utterances otherwise.

The test utterances of both one-syllable and two-syllables were recorded on magnetic tape in a sound-proof room by a female speaker of Hanoi dialect. Another female informant recorded part of the corpus. Two male informants were available to check some unclear cases in our

[6]G. Sampson, "Hanoi Dorsal Finals," Bulletin of the Oriental and African Studies, University of London, Vol. XXXII, Part I, 1969.

principal informant's speech. Each of the female informants recorded each of the test utterances in the frame:

/tō i dɔ̄k cw̃ ___$_0$, ___$_1$, ___$_2$, ___$_3$./

"I read the word ___$_0$, ___$_1$, ___$_2$, ___$_3$."

The first three syllables in the frame, that is /tō i dɔ̄k cw̃/ were positioned mainly to provide the informant with a reference pitch level rather than to put the test utterances in a sentential environment. The informants were instructed to put a brief pause of approximately one second after each repetition of the test utterance. The informants were also asked to maintain during the four repetitions of each test utterance the same pitch level as much as possible, and not to lower the pitch of the later repetitions.

Narrow-band spectrograms were made from the recordings made in this manner. A close examination of the spectrograms revealed that the pitch contour of the first repetition of the test utterances was considerably different from that of the other three repetitions, which seemed to be the result of the influence of the high end-point pitch of the immediately preceding syllable /cw̃/. Thus the syllable which is numbered "0" in the above frame was not used in the present analysis. The remaining three repeti-

tions are similar in their pitch contour. In many cases the overall pitch level of each repetition gradually falls as it approaches the last syllable. This phenomenon, however, is not consistent throughout our recordings, and we, therefore, ignored it in this study.

On each spectrogram the 10th harmonic was measured and then converted into f_o. In measuring the spectrograms, we tried to be consistent in the following procedures:

1. If a syllable begins with a consonant, the initial point of the following vowel was taken as the onset of the tone. Voiced consonants in the syllable initial position do not affect the pitch contour of the syllable.

2. If a syllable begins with a vowel, then the beginning of the steady portion of the harmonics was taken as the onset of the tone. It was consistently observed that a very sharp rise of pitch occurs in the first 5 to 10 centiseconds of the beginning of such vowels, which seems to be caused by the sudden release of the laryngeal constriction during the glottal stop which occurs typically in such environments.

3. As to the intermediate points, only those points where a significant pitch change occurs were measured. Thus the pitch of any intermediate point can be calculated by linear interpolation between two adjacent measurements.

4. When a syllable ends in a nasal, the nasal participates in shaping the pitch contour of the tone, and the measurements were taken with the nasals.

5. In many cases in which the higher harmonics were faint, the 5th or even the 2nd harmonic was measured.

From the description of our material and method, one might suspect the accuracy of our analysis because we ignored the effect of some factors such as the different degree of influence of fricatives, stops, nasals, and others on the f_0 of the syllable nucleus. But in the following pages, it will become clear that even a 5 to 10 Hz difference is, at least in our principal informant's speech, insignificant.

Results

1. Tones in One-Syllable Utterances

Table 1-A shows all the measurements of one-syllable utterances by our principal informant. Table 1-B presents the average f_0 values obtained from Table 1-A of the six tones. Measurements were taken at four points in time; at the onset, the mid, the two-thirds, and the end of the syllable.

Table 1-A

Fundamental Frequency Measurements of One-Syllable Utterances

(in Hz)

Frame: [tʃɪ dʒɜ cʊ̄ 0. 1 2 3.]

level tone

	onset	mid	end
bX̄			
1	220	250	250
2	230	255	250
3	230	250	240
bX̄n			
1	235	250	250
2	225	240	250
3	225	240	245
dX̄			
1	230	245	250
2	225	245	245
3	220	245	245
dX̄n			
1	240	280	280
2	240	260	265
3	245	260	265
dX̄ŋ			
1	235	260	255
2	235	255	260
3	235	260	260
gX̄			
1	245	250	250
2	235	250	250
3	230	245	240
gX̄n			
1	255	250	255
2	230	250	250
3	230	245	245
gX̄ŋ			
1	220	240	240
2	225	245	245
3	230	245	245
lX̄			
1	240	255	255
2	245	250	250
3	240	255	245
lX̄m			
1	235	250	250
2	235	245	250
3	235	245	245
lX̄n			
1	250	270	265
2	240	260	260
3	250	265	260
mX̄			
1	240	255	260
2	235	250	255
3	245	255	260
mX̄n			
1	240	255	255
2	240	255	255
3	240	250	255
total	9160	9830	9850
ave.	234.8	252.0	252.5

rising tone

	onset	2/3	end
bX́			
1	215	240	410
2	225	255	370
3	220	235	370
bX́k			
1	255	275	340
2	240	275	330
3	245	275	340
bX́m			
1	205	240	340
2	230	245	360
3	220	240	340
bX́n			
1	205	230	350
2	205	225	330
3	215	225	320
bX́t			
1	225	275	340
2	235	280	350
3	235	265	350
dX́			
1	205	230	380
2	215	225	350
3	215	225	340
dX́m			
1	205	225	330
2	220	230	330
3	220	235	340
dX́ŋ			
1	205	230	370
2	215	245	360
3	205	225	325
dX́p			
1	220	270	350
2	230	290	350
3	240	285	330
gX́k			
1	220	275	335
2	220	270	330
3	225	265	325
lX́			
1	225	255	340
2	225	240	320
3	225	235	325
lX́k			
1	225	290	345
2	240	280	340
3	240	290	330
lX́ŋ			
1	215	250	350
2	225	250	320
3	225	235	320
lX́t			
1	230	280	335
2	240	290	335
3	255	290	335
mX́			
1	215	235	350
2	215	245	320
3	215	245	350
mX́n			
1	215	240	380
2	220	245	330
3	220	235	330
mX́t			
1	225	270	305
2	230	270	325
3	235	280	340
total	11375	12955	17410
ave.	223.3	254.0	341.3

falling tone

	onset	mid	end
bX̀			
1	195	195	165
2	190	190	170
3	185	175	160
bX̀n			
1	195	195	175
2	190	185	170
3	180	175	155
bX̀ŋ			
1	190	190	175
2	185	185	175
3	180	175	155
dX̀			
1	195	185	175
2	185	180	165
3	180	170	155
dX̀m			
1	195	195	180
2	190	195	180
3	185	180	170
dX̀n			
1	195	190	170
2	195	190	180
3	185	180	170
gX̀			
1	195	190	175
2	185	180	170
3	185	175	165
gX̀n			
1	200	195	170
2	180	185	175
3	180	180	165
lX̀			
1	190	185	165
2	190	190	170
3	185	180	160
lX̀m			
1	190	190	175
2	185	185	175
3	190	185	170
lX̀n			
1	195	190	185
2	185	185	180
3	185	180	175
lX̀ŋ			
1	205	195	175
2	185	185	170
3	185	180	165
mX̀			
1	185	180	170
2	185	180	165
3	180	175	165
mX̀n			
1	190	185	175
2	180	180	170
3	185	175	170
mX̀ŋ			
1	195	190	175
2	190	185	180
3	190	180	170
total	8470	8295	7670
ave.	188.2	184.3	170.4

broken tone

	onset	2/3	end
bX̌			
1	215	?	365
2	220	?	390
3	210	?	390
dX̌			
1	215	?	380
2	210	?	390
3	205	?	370
dX̌ŋ			
1	220	?	360
2	210	?	340
3	210	?	340
gX̌			
1	220	?	400
2	220	?	365
3	215	?	350
lX̌			
1	215	?	380
2	215	?	380
3	215	?	380
lX̌m			
1	225	?	390
2	225	?	390
3	220	?	390
lX̌ŋ			
1	220	?	370
2	225	?	350
3	215	?	345
mX̌			
1	215	?	390
2	220	?	370
3	215	?	575
total	5195		8950
ave.	216.4		372.9

curve tone

	onset	2/3	end
bX̆			
1	175	150	195
2	170	155	195
3	170	155	185
bX̆n			
1	180	155	200
2	185	155	190
3	175	165	190
bX̆ŋ			
1	185	150	175
2	185	150	210
3	180	140	190
dX̆			
1	185	170	235
2	180	150	185
3	175	150	185
dX̆m			
1	190	145	195
2	180	150	180
3	180	150	185
dX̆n			
1	185	145	185
2	175	155	200
3	175	150	200
dX̆ŋ			
1	185	150	205
2	180	150	195
3	185	150	190
gX̆			
1	180	155	240
2	175	170	215
3	170	160	215
lX̆			
1	180	155	195
2	175	150	205
3	175	150	185
lX̆ŋ			
1	185	170	215
2	180	150	195
3	180	165	215
mX̆			
1	180	155	210
2	180	165	210
3	175	155	185
mX̆ŋ			
1	185	165	205
2	185	160	205
3	180	160	185
total	6465	5575	7150
ave.	179.5	154.8	198.6

drop tone

	onset	2/3	end
bX̂			
1	205	205	?
2	195	190	?
3	200	195	?
bX̂k			
1	195	195	?
2	195	195	?
3	195	185	?
bX̂n			
1	200	200	?
2	190	195	?
3	195	195	?
dX̂n			
1	200	200	?
2	195	190	?
3	195	195	?
dX̂p			
1	185	195	?
2	190	190	?
3	185	185	?
dX̂t			
1	180	180	?
2	185	185	?
3	185	185	?
gX̂			
1	190	180	?
2	185	185	?
3	190	190	?
gX̂k			
1	195	190	?
2	195	185	?
3	190	185	?
gX̂t			
1	200	185	?
2	185	185	?
3	185	180	?
lX̂			
1	185	175	?
2	185	175	?
3	170	165	?
lX̂ŋ			
1	215	200	?
2	195	195	?
3	200	200	?
lX̂t			
1	205	205	?
2	190	195	?
3	195	190	?
mX̂			
1	195	200	?
2	190	190	?
3	195	190	?
mX̂n			
1	195	190	?
2	200	200	?
3	200	195	?
mX̂ŋ			
1	200	200	?
2	190	195	?
3	190	190	?
mX̂t			
1	185	190	?
2	190	185	?
3	185	180	?
total	9240	9130	
ave.	192.5	190.2	

Table 1-B

Average Fundamental Frequency of the Six Tones (in Hz)

Tone		No. of Occurrences	Onset	Mid	2/3	End
level	/-/	39	235	252		253
rising	/ˊ/	51	223		254	341
broken	/˜/	24	216		?	373
falling	/ˋ/	45	188	184		170
curve	/ˇ/	36	180		155	199
drop	/¬/	48	193		190	?

The ? mark represents a heavy laryngealization. On the spectrograms, harmonics around these points are interrupted and the exact f_0 values were not measurable.

Figure 1 is the schematic representation of the pitch contour of the six tones derived from the average f_0's presented in Table 1-B. The duration of the syllable is approximately the same as the average duration of the syllables observed on the spectrograms.

Figure 1

Schematic Representations of the Six Tones in One-Syllable Utterances

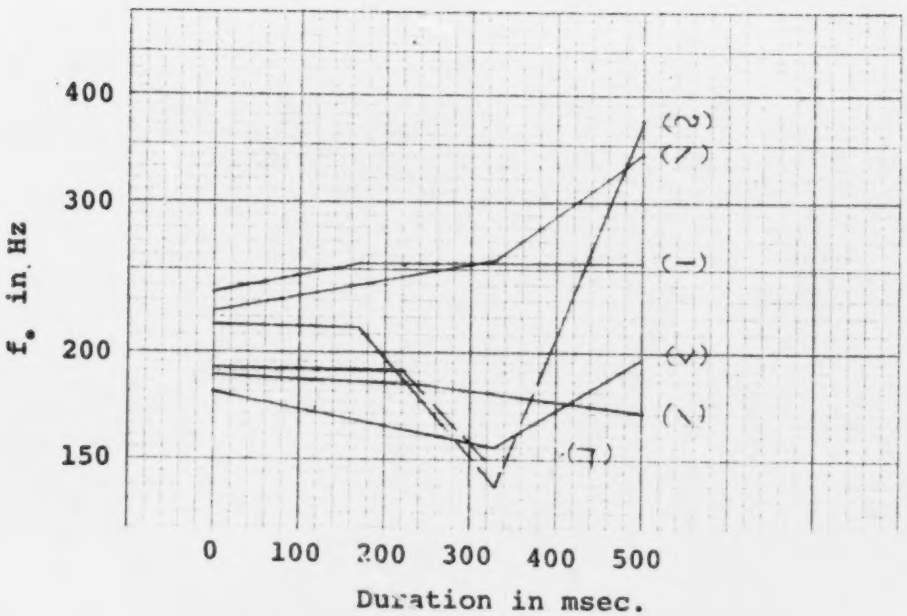

Figure 1 differs only in minor respect from our previous study. Han (1969) presented a similar figure based on the analysis of syllables composed only of a vowel. The slightly rising slope in the first third of the level tone /-/ seems to be a characteristic of this informant. With other informants, this was not observed to be consis-

tent.

The general characteristics of the six tones are as follows:

a. Level Tone /-/: The onset value of the f_0 is the highest of all the six tones. The steady state of the level contour is always observed. The slight pitch rise at the onset, about 1.2 semitones, seems to be an idiosyncratic feature of our principal informant. Such a rise is rarely observed in other informant's speech. Even in the principal informant's speech this rise is not consistent. Thus we will not regard this feature as distinctive with regard to the level tone.

b. Rising Tone /ˊ/: The onset value of the f_0 is relatively high. From the high onset, the pitch gradually rises until a point representing two-thirds of the duration of the syllable nucleus. From this point, the pitch rises more rapidly. The pitch rise from the onset-point to the end-point is as great as 9 semitones (118 Hz.). The pitch rise in the first portion is about one quarter of the entire rise.

c. Broken Tone /˜/: The onset value of the f_0 is high. There is a brief period of level pitch in the first third. In the second third, a strong

laryngealization occurs and the frequency drops abruptly resulting in creaky voice. The last third is characterized by a very sharp pitch rise. The pitch difference between the onset-point and end-point is approximately 12 semitones (157 Hz.).

d. Falling Tone /ˋ/: This tone is characterized by its low onset value of the f_0 and a gradual pitch fall to the end-point. The pitch fall is about 1.7 semitones (18 Hz.).

e. Curve Tone /ˇ/: The onset value of the f_0 is lowest among the six tones. The low pitch at the onset falls gradually to a point representing two-thirds of the duration of the syllable nucleus. From here, the pitch rises gradually to the end. The pitch fall in the first portion is 2.7 semitones (25 Hz.) and the pitch rise at the end is 4.7 semitones (44 Hz.). With other informants the amount of pitch rise in the second portion is much smaller.

f. Drop Tone /¬/: The onset value of the f_0 is higher than that of the falling and curve tones but lower than the other tones. This tone is characterized by a slight pitch fall in the first two-thirds and an abrupt pitch fall in the last third which is accompanied by laryngealization. With most

informants, the duration of this tone is much shorter, about two-thirds of the duration for the other tones.

In the above discussion we have pointed out that the onset value of the f_0 for one tone is higher or lower relative to that of the other tones. As seen in Figure 1, the f_0 of the onset-point is highest in the level tone and lowest in the curve tone, the difference between them being 5.1 semitones (55 Hz.). Within this range the onset-points of the six tones are distributed in such a way that the onset of the level, rising, and broken tones are higher than those of the other three tones. On the other hand, the pitch range representing end-points of the six tones is much greater. The difference between the highest and lowest end-points, (the broken and falling tones respectively), is 19.9 semitones (203 Hz.). The end-point of the drop tone is even lower than that of the falling tone, but since the f_0 of the end-point is hardly measurable on the spectrograms due to heavy laryngealization the end-point of the falling tone was taken as the lowest. However, the size of these ranges depends upon the average voice fundamental of the speaker. For example, in the speech of Informant 4 (male) in Han (1969), whose average voice fundamental is in the vicinity of 140 Hz., the pitch ranges of the onset and end-

points of the six tones are 1.5 semitones (12 Hz.) and 10.5 semitones (71 Hz.) respectively.

It can be seen in Table 1-B and Figure 1 that the three tones which have relatively high onset f_0 values also have higher end-points than those for the falling, curve, and drop tones. For the sake of reference, we will refer to the three tones with high onset and end f_0 values (i.e., level, rising, and broken) as high tones, and the remaining three as low tones.

2. Tone Variation in Two-Syllable Utterances

Table 2-A in the following 15 pages presents the measurements of the f_0 for all the two-syllable test utterances used for this study. This table contains all thirty-six possible combinations of the six tones on two-syllable words, and the points of measurement are the same as those described for one-syllable utterances in the preceding section. The rows numbered 1, 2, and 3 are the three repetitions of the two-syllable utterances whose phonemic representations are given at the left top above the three rows. In each row, the f_0 measurements of the first and second syllables are given. The mark ? represents laryngealization. The grand total of the f_0 values for each point of measurement and also the average are given at the end of the measurements for all the test utterances of each type.

Table 2-A

Fundamental Frequency Measurements of Two-Syllable Utterances

(in Hz)

a. LEVEL + OTHER COMBINATIONS

1. Level + Level

		First Syllable			Second Syllable		
		onset	mid	end	onset	mid	end
Xn ŭm							
	1	300	300	295	275	285	280
	2	280	280	280	265	270	270
	3	275	275	275	260	265	265
Xn zXn							
	1	295	295	295	290	290	295
	2	285	285	285	280	285	285
	3	280	280	280	275	280	280
zX ĭŠŋ							
	1	255	265	285	285	290	290
	2	265	285	285	280	280	280
	3	255	270	270	280	280	280
zXĭ gXĭ							
	1	270	295	295	280	290	290
	2	265	295	295	280	285	295
	3	265	285	285	270	285	285
zŭ zXn							
	1	275	295	285	295	290	290
	2	280	295	290	280	275	290
	3	270	290	290	285	295	295
dŠ ŋŠn							
	1	235	270	270	285	285	295
	2	240	270	270	285	285	285
	3	255	275	275	275	280	280
dXu zXŋ							
	1	260	280	280	285	285	285
	2	235	265	280	270	280	280
	3	235	270	270	265	270	265
zXu zŭ							
	1	250	270	275	275	280	280
	2	255	275	280	265	270	270
	3	255	275	280	260	270	270
lXu nXn							
	1	250	270	280	275	280	280
	2	250	275	275	270	270	275
	3	255	265	275	275	275	275

		First Syllable			Second Syllable		
		onset	mid	end	onset	mid	end
muŠn nXn							
	1	270	275	280	275	275	275
	2	255	270	305	305	275	270
	3	250	270	275	270	270	270
ŋXŋ nXu							
	1	245	255	265	265	265	270
	2	245	275	275	260	265	260
	3	255	280	280	265	270	270
nŠŋ zXn							
	1	260	290	280	270	280	285
	2	255	285	280	265	275	280
	3	255	285	275	265	280	275
vXn zX							
	1	250	275	270	265	275	265
	2	240	265	260	260	265	255
	3	245	260	265	265	265	255
bX lŠ							
	1	235	250	275	270	270	270
	2	235	250	260	265	275	260
	3	240	250	255	255	260	260
bXn Xn							
	1	240	260	270	260	275	265
	2	235	255	265	255	260	265
	3	245	260	265	245	260	260
zXn pŠ							
	1	255	280	290	260	270	270
	2	255	270	275	260	265	265
	3	250	265	270	260	255	260
dXm mŠ							
	1	230	255	260	255	260	255
	2	230	255	260	250	260	245
	3	235	250	245	245	250	250
dXu dXu							
	1	250	270	270	265	270	265
	2	250	275	275	260	265	270
	3	245	260	265	255	270	265

		First Syllable			Second Syllable		
		onset	mid	end	onset	mid	end
lXT zXT							
	1	240	265	265	260	270	255
	2	250	265	265	255	250	265
	3	235	260	260	245	255	255
lXŋ bXŋ							
	1	245	270	260	250	260	265
	2	240	255	260	250	260	265
	3	230	245	255	245	250	260
lXu dXu							
	1	255	260	260	255	255	260
	2	245	265	265	250	250	255
	3	240	255	260	245	245	250
mŠ mXn							
	1	245	255	255	255	255	260
	2	240	255	255	245	250	255
	3	235	245	245	235	245	255
mŠŋ mXp							
	1	255	270	270	275	280	285
	2	245	255	265	270	275	280
	3	245	260	265	270	270	270
ŋXm ŋX							
	1	270	270	270	270	275	275
	2	265	285	275	280	280	275
	3	260	280	280	275	280	280
ŋŠ ŋŠ							
	1	255	280	290	280	275	290
	2	260	275	275	275	275	290
	3	260	275	280	280	275	280

total		18965	20300	20485	20020	20330	20380
ave.		252.8	270.6	273.1	266.9	271.0	271.7

2. Level + Rising

		First Syllable			Second Syllable		
		onset	mid	end	onset	2/3	end
Šn bđt							
	1	305	305	295	290	325	415
	2	305	305	290	285	325	410
	3	280	280	275	275	310	390
Xn Áu							
	1	270	275	270	235	250	390
	2	275	280	265	245	255	390
	3	255	265	260	235	245	380
Xn Áĭ							
	1	285	285	285	255	245	375
	2	275	275	275	245	245	355
	3	265	265	265	235	235	315
buŠn bÁn							
	1	260	295	280	260	260	330
	2	265	295	270	255	255	310
	3	260	290	270	250	250	305
dXŋ ldŭ							
	1	250	265	265	260	305	350
	2	270	285	285	260	285	345
	3	255	275	270	250	285	335
dŠu đđŋ							
	1	235	265	275	245	240	320
	2	240	265	260	240	245	310
	3	235	255	260	230	230	280
dŠ đđn							
	1	250	285	285	255	245	310
	2	250	270	275	255	245	295
	3	245	270	265	240	235	295

		First Syllable			Second Syllable		
		onset	mid	end	onset	2/3	end
dŠn nŕu							
	1	250	270	290	270	250	370
	2	245	270	270	255	240	330
	3	240	260	270	250	240	310
ŭm gÁĭ							
	1	270	270	265	240	235	320
	2	260	265	265	240	235	325
	3	255	260	260	240	230	320
ŭu dŕt							
	1	260	260	260	260	295	355
	2	260	260	260	260	300	355
	3	255	260	255	260	290	355
Šm Áĭ							
	1	275	275	280	250	255	350
	2	275	270	275	235	235	320
	3	260	265	270	250	250	315
gXĭ wđt							
	1	285	305	295	310	340	380
	2	280	285	275	295	310	390
	3	250	275	275	275	280	340
Xĭ dlđu							
	1	285	285	285	265	265	330
	2	270	270	265	255	245	310
	3	250	250	255	230	230	285
bŠŋ zÁ							
	1	270	295	290	255	240	310
	2	260	280	280	245	250	320
	3	245	280	265	240	235	315

		First Syllable			Second Syllable		
		onset	mid	end	onset	2/3	end
zŭ zđĭ							
	1	275	310	300	275	270	360
	2	260	275	275	265	245	305
	3	260	275	270	240	235	280
zŭĭ pŕt							
	1	275	300	295	305	345	410
	2	275	300	295	310	360	430
	3	265	290	285	285	300	340
dXŋ oÁ							
	1	255	290	275	250	240	345
	2	260	285	290	240	235	280
	3	245	255	275	240	230	265
dŠu đđn							
	1	245	280	275	245	250	290
	2	260	270	270	245	245	320
	3	240	250	260	240	240	290
ŭu ŭu							
	1	270	270	260	255	240	330
	2	255	255	255	250	235	330
	3	245	245	245	230	225	320
gXĭ gŝk							
	1	250	290	280	285	310	370
	2	250	285	280	275	300	340
	3	255	280	275	285	300	340
gXĭ gđt							
	1	250	280	280	295	300	300
	2	250	280	275	285	310	370
	3	260	275	270	270	280	340

total		16430	17405	17230	16250	16660	21145
ave.		260.7	276.2	273.4	257.9	264.4	335.6

3. Level + Broken

	First Syllable			Second Syllable	
	onset	mid	end	onset	end
¤n ¡Ål					
1	310	310	305	275	375
2	310	315	310	285	370
3	305	305	285	275	365
bTn qū					
1	280	310	300	285	360
2	285	295	290	270	380
3	295	295	280	265	400
zÅ mÅu					
1	275	280	290	265	350
2	280	280	290	260	340
3	280	280	290	260	370
nBn zō					
1	260	290	280	270	345
2	275	295	285	260	360
3	280	300	285	255	340
pXn mÅn					
1	280	295	285	265	380
2	295	295	285	270	360
3	285	290	280	260	380
¤ō ¡Åu					
1	310	310	300	285	340
2	295	295	295	275	310
3	290	290	285	260	330
zō¦ vÅ¦					
1	275	300	300	285	390
2	280	295	290	275	390
3	280	295	295	275	360
vÆ¦ ¡Å¦					
1	280	295	285	275	370
2	265	285	280	260	390
3	275	285	270	260	385

	First Syllable			Second Syllable	
	onset	mid	end	onset	end
vō ¡¤					
1	280	295	295	290	380
2	275	285	285	270	375
3	270	285	275	265	360
pō pÅ					
1	280	300	305	285	380
2	270	280	285	265	350
3	280	290	290	265	370
¦uBn mÅ¦					
1	275	295	295	275	385
2	285	305	305	270	375
3	295	305	305	275	385
Xp vū					
1	315	315	315	250	380
2	305	310	270	250	350
3	295	305	295	250	370
bXn nā¦					
1	285	285	280	275	375
2	275	300	290	280	385
3	270	295	285	270	380
bō ¡Åu					
1	285	310	310	285	355
2	270	280	275	270	330
3	275	280	280	260	310
zū dÅq					
1	280	310	290	290	400
2	280	310	290	265	410
3	275	300	300	270	400
zū ¡Åm					
1	290	320	310	300	410
2	285	310	300	295	420
3	280	290	290	295	380

	First Syllable			Second Syllable	
	onset	mid	end	onset	end
zū¦ qÅ					
1	300	315	310	295	365
2	300	315	305	285	390
3	290	300	300	275	370
dBu bÅu					
1	270	315	315	275	370
2	280	310	310	275	350
3	275	295	295	265	370
¡Xl vÅq					
1	280	305	295	290	360
2	280	300	295	275	350
3	275	285	280	265	350
¡Bl vū					
1	290	320	310	250	380
2	275	315	315	250	380
3	280	285	295	250	380
¡Bq vū					
1	280	325	320	260	380
2	285	315	310	270	370
3	280	295	290	250	360
quXn quÅn					
1	310	320	330	295	410
2	305	315	305	280	390
3	285	305	305	265	380
qū ¡¤					
1	275	290	285	275	400
2	305	315	310	285	390
3	285	300	295	280	370
pXn zūq					
1	280	310	310	275	410
2	295	320	310	275	420
3	290	305	305	270	410
Total	20450	21620	21260	19565	26850
Ave.	284.0	300.6	295.2	271.7	372.9

4. Level + Falling

	First Syllable			Second Syllable		
	onset	mid	end	onset	mid	end
¤m zÅ¦						
1	270	270	270	225	210	195
2	265	265	265	220	210	195
3	240	240	240	210	195	180
gXn gÅ						
1	240	250	265	225	205	180
2	215	235	245	215	200	175
3	210	220	225	200	190	170
gō bÅu						
1	245	260	245	215	205	195
2	225	235	230	215	200	185
3	220	230	225	200	190	180
mū xÅo						
1	265	270	275	235	210	175
2	245	255	255	220	200	175
3	225	245	235	205	200	175
qō dÅn						
1	245	255	255	220	210	190
2	225	245	240	225	200	190
3	220	225	230	205	200	190
qBn ¡Åp						
1	230	245	265	240	215	215
2	220	240	255	230	215	205
3	215	225	235	220	200	195
qū dÅn						
1	250	265	265	235	215	190
2	225	260	260	230	210	190
3	230	245	250	225	205	175
Bq bÅu						
1	255	255	255	230	195	180
2	230	235	240	220	190	180
3	225	230	230	210	185	175

	First Syllable			Second Syllable		
	onset	mid	end	onset	mid	end
zX dÅ¦						
1	235	235	240	205	190	185
2	230	225	235	210	195	180
3	220	225	230	205	190	175
f zÅ						
1	255	255	255	230	205	180
2	245	245	240	215	190	180
3	235	235	235	210	180	175
¤m dÅu						
1	265	265	265	225	215	195
2	250	255	255	220	200	195
3	240	240	240	215	195	190
zX dÅq						
1	250	265	265	225	210	195
2	240	250	250	215	205	190
3	240	250	250	215	210	195
zX dÅmq						
1	240	250	255	220	210	185
2	225	240	245	210	200	180
3	225	230	230	205	200	180
mBn bÅ¦						
1	240	275	270	230	205	190
2	230	265	250	220	205	195
3	215	255	250	210	185	185
mBn dō						
1	225	275	260	230	205	190
2	215	255	255	220	205	190
3	220	245	245	210	210	190
mÆ mÅō						
1	235	270	275	240	210	195
2	235	270	260	240	210	185
3	240	260	260	225	200	180

	First Syllable			Second Syllable		
	onset	mid	end	onset	mid	end
mÆ mdq						
1	235	265	265	250	210	195
2	235	260	265	235	210	200
3	230	260	255	220	200	190
mBo ¡dq						
1	260	275	270	230	215	195
2	255	265	265	235	210	195
3	240	250	250	225	195	190
dm dÅu						
1	235	240	245	225	190	180
2	225	230	235	210	190	180
3	225	230	230	210	190	180
ōq zÅ						
1	265	265	260	220	200	155
2	245	250	250	220	195	185
3	240	240	240	215	185	180
quXn dāq						
1	230	260	275	220	205	195
2	240	270	265	220	205	195
3	230	250	255	220	200	190
¤ mÅu						
1	240	250	255	220	205	180
2	215	220	240	215	195	180
3	215	225	250	210	190	180
zBq zÅ¦						
1	245	265	260	225	205	190
2	235	245	245	215	195	185
3	215	225	230	205	185	180
¤ nÅn						
1	270	270	265	235	210	195
2	250	250	250	235	210	190
3	245	245	245	225	200	175
Total	17005	17940	18015	15865	14480	13395
Ave.	236.1	249.1	250.2	220.3	201.1	186.0

5. Level + Curve

	First Syllable			Second Syllable		
	onset	mid	end	onset	2/3	end
X̄n zə̄						
1	280	280	280	220	145	145
2	270	270	260	215	155	155
3	265	265	260	210	160	160
X̄n zÃi						
1	280	280	280	225	140	140
2	260	260	275	225	125	125
3	255	255	255	210	130	145
bX̄ bĪi						
1	225	255	275	225	160	160
2	225	255	260	215	160	160
3	215	245	250	210	150	150
dw̄u dĭ						
1	235	270	275	230	140	140
2	225	265	270	235	160	160
3	225	260	260	215	155	155
dw̄n də̄						
1	235	275	280	240	165	165
2	235	260	265	225	155	155
3	225	250	255	210	155	155
dō̄ŋ dŭ						
1	240	290	285	230	165	165
2	235	280	275	220	155	155
3	220	260	260	210	160	160
X̄m zə̄						
1	255	260	260	230	140	140
2	260	265	270	220	140	140
3	250	255	255	220	135	135
w̄m X̄m						
1	255	255	265	215	185	185
2	260	260	265	205	140	140
3	250	250	250	210	160	160
nX̄ŋ bō̄ŋ						
1	260	285	275	225	160	210
2	245	280	265	230	155	195
3	245	265	260	220	155	180

	First Syllable			Second Syllable		
	onset	mid	end	onset	2/3	end
X̄n ðə						
1	280	280	280	205	165	170
2	265	265	270	210	160	160
3	250	250	260	195	160	170
X̄n ðĭ						
1	280	280	280	230	165	170
2	250	260	265	190	165	165
3	255	260	265	215	165	165
zŪŋ zÃi						
1	250	285	280	235	165	165
2	250	280	280	220	150	150
3	250	275	270	215	150	170
dō̄ŋ dÃu						
1	240	275	270	245	175	175
2	235	275	265	235	145	145
3	230	260	255	230	135	135
mw̄i zŭi						
1	255	270	270	220	150	150
2	240	265	260	205	155	150
3	235	260	255	190	160	160
mX̄ ðan						
1	245	265	265	220	170	170
2	245	270	270	195	170	170
3	230	260	255	210	145	145
nw̄n zÃi						
1	235	275	280	225	155	155
2	255	270	260	220	150	150
3	230	250	260	215	145	170
vw̄ vX̄n						
1	250	280	280	235	155	155
2	235	270	270	225	155	155
3	240	275	275	215	150	150
Total	12560	13605	13625	11145	7865	8055
Ave.	246.2	266.7	267.1	218.5	154.2	157.9

6. Level + Drop

	First Syllable			Second Syllable		
	onset	mid	end	onset	2/3	end
w̄n bÃn						
1	300	300	290	235	220	?
2	280	280	280	235	220	?
3	270	270	270	230	205	?
bw̄n mw̄t						
1	275	275	275	245	215	?
2	260	260	260	235	210	?
3	240	245	245	225	200	?
gX̄n zĀ						
1	250	290	285	230	200	?
2	245	290	290	235	215	?
3	235	280	280	225	210	?
zŪŋ dō̄ŋ						
1	255	290	280	255	220	?
2	265	290	275	245	215	?
3	255	275	265	235	215	?
vw̄ zŪŋ						
1	265	295	290	245	210	?
2	255	285	280	245	210	?
3	250	270	265	230	200	?
vw̄ dÃu						
1	260	280	265	250	220	?
2	255	275	265	235	200	?
3	245	265	260	235	195	?
vw̄ vX̄t						
1	270	290	290	250	210	?
2	255	275	280	225	195	?
3	250	255	250	225	185	?

	First Syllable			Second Syllable		
	onset	mid	end	onset	2/3	end
dX̄ zŪk						
1	245	260	270	225	190	?
2	235	265	270	225	190	?
3	230	255	265	215	170	?
pX̄n dÃu						
1	245	290	290	250	205	?
2	245	280	280	245	220	?
3	240	265	265	235	185	?
pw̄ dÃu						
1	260	290	290	255	205	?
2	245	270	270	245	210	?
3	240	255	255	235	185	?
nw̄ lə̄						
1	245	275	275	250	200	?
2	245	270	265	245	175	?
3	240	265	260	235	195	?
ū dō̄ŋ						
1	240	265	265	250	205	?
2	250	275	260	240	200	?
3	230	245	250	235	185	?
vX̄ŋ zō̄i						
1	245	255	290	245	215	?
2	240	245	275	240	210	?
3	235	245	265	230	185	?
Total	9790	10605	10600	9270	7900	
Ave.	251.0	271.9	271.7	237.6	202.5	

b. RISING + OTHER COMBINATIONS

1. Rising + Level

	First Syllable			Second Syllable		
	onset	2/3	end	onset	mid	end
bÁu ¯n						
1	210	225	270	305	290	290
2	210	235	270	290	280	280
3	225	240	290	270	270	270
bát z¯m						
1	260	275	400	275	285	280
2	260	275	360	275	275	275
3	260	275	330	265	275	265
bǒŋ z¯ŋ						
1	225	230	290	310	290	280
2	220	240	310	300	275	270
3	220	220	290	285	260	260
bůt tˇŋ						
1	230		330	280	280	280
2	230		360	275	275	280
3	250		300	260	275	275
dÁ b¯n						
1	215	225	300	275	275	270
2	225	225	305	275	265	265
3	230	240	290	260	260	265
dÁp dˇ						
1	225	225	295	320	305	290
2	235	225	260	300	290	290
3	225	225	265	285	285	275

	First Syllable			Second Syllable		
	onset	2/3	end	onset	mid	end
dáp dˇ						
1	250	280	325	260	265	265
2	260	275	320	260	260	260
3	250	280	320	245	255	250
dé dˇ						
1	225	240	310	280	280	275
2	220	250	290	275	270	265
3	225	245	280	260	275	270
dán n¯l						
1	220	235	260	325	295	310
2	245	260	310	315	300	295
3	245	245	310	305	290	295
zÁ bŪon						
1	225	230	310	295	295	295
2	235	250	310	295	295	295
3	235	235	295	285	285	285
zÁp p¯u						
1	240	270	305	275	265	265
2	280	285	320	275	260	260
3	245	265	310	270	270	260
zǒ dˇŋ						
1	225	235	310	275	290	290
2	235	240	325	285	285	285
3	230	235	305	265	280	265

	First Syllable			Second Syllable		
	onset	2/3	end	onset	mid	end
lǎu ¯n						
1	230	230	300	285	275	275
2	230	230	280	290	290	280
3	230	235	270	290	280	280
lǎŋ qˇ						
1	235	235	300	295	290	285
2	235	250	280	295	285	280
3	230	245	285	290	280	275
lǎn l¯u						
1	225	245	260	315	285	280
2	245	255	275	315	285	265
3	240	255	275	300	275	265
mǎo m¯l						
1	215	255	300	320	300	285
2	245	270	295	305	295	285
3	230	255	280	300	290	285
pÁp pš						
1	220	275	360	280	295	280
2	255	310	375	290	285	275
3	255	295	400	280	280	275
zǒi bˇŋ						
1	240	250	315	290	290	285
2	240	250	310	285	285	275
3	230	250	295	270	270	275
Total	12675	12725	16485	15435	15160	14950
Ave.	234.7	249.5	305.2	285.8	280.7	276.8

2. Rising + Rising

	First Syllable			Second Syllable		
	onset	2/3	end	onset	2/3	end
zÁu vˇt						
1	230	235	280	340	360	390
2	240	235	300	320	330	365
3	220	240	270	325	340	360
dÁp bǒŋ						
1	215	220	280	275	250	320
2	250	245	295	275	245	320
3	250	250	280	260	250	310
dÁp zÁu						
1	230	230	285	265	245	340
2	245	240	300	260	230	290
3	240	235	280	260	230	330
dÁp dǒ						
1	235	235	295	265	250	320
2	240	235	270	250	245	300
3	235	230	270	260	250	300
dám bǎp						
1	230	250	275	320	325	390
2	225	250	290	320	335	360
3	230	260	260	320	330	380
dám dÁ						
1	220	245	270	275	260	345
2	225	250	280	260	250	335
3	240	255	270	255	245	320
dǎu zÁ						
1	225	255	300	290	270	360
2	240	245	290	280	245	330
3	240	250	320	250	240	325
dǒŋ zǎu						
1	230	230	300	270	265	300
2	250	235	300	280	265	290
3	230	270	300	280	250	300

	First Syllable			Second Syllable		
	onset	2/3	end	onset	2/3	end
zÁ bǎn						
1	230	250	310	275	260	350
2	260	255	295	270	255	330
3	275	260	290	255	240	330
zǎu zǒi						
1	230	225	275	275	265	310
2	260	240	310	270	265	310
3	270	240	295	265	265	315
zǒ lǒk						
1	235	250	315	330	360	400
2	240	255	305	330	355	380
3	235	255	305	330	355	395
lǎm lǒk						
1	225	250	290	315	315	420
2	255	280	290	320	360	410
3	240	280	290	350	330	420
nám dám						
1	240	245	350	285	275	420
2	265	270	320	270	270	370
3	250	270	320	265	260	375
bát zǎk						
1	240	270	410	350	395	430
2	290	315	370	325	330	420
3	315	320	375	315	320	400
bát bé						
1	260	320	395	260	270	330
2	330	340	395	255	255	320
3	305	315	380	250	255	310
zǎŋ zǎp						
1	240	240	320	360	370	410
2	240	260	300	330	340	390
3	255	255	325	330	310	370

	First Syllable			Second Syllable		
	onset	2/3	end	onset	2/3	end
zǎm zǒi						
1	250	280	315	300	290	410
2	265	290	320	270	300	500
3	250	270	310	260	280	360
zǔm zš						
1	230	250	320	300	260	370
2	250	270	320	280	255	375
3	240	260	310	255	345	
dǎp dǎn						
1	215	210	330	295	275	365
2	245	240	310	275	260	370
3	245	250	325	275	250	350
zÁ bǎot						
1	230	270	330	320	330	400
2	245	260	320	320	330	420
3	240	250	320	320	330	430
zǎ¯ zǎp						
1	235	250	305	365	375	450
2	245	275	305	340	355	455
3	255	270	320	325	340	430
lǎu lǎu						
1	235	265	345	300	265	400
2	250	295	350	285	265	380
3	255	280	330	285	265	390
lǎŋ lǎp						
1	230	265	345	295	270	380
2	250	280	325	270	260	370
3	240	280	325	285	270	390
nǎn nǒt						
1	235	265	300	345	360	410
2	240	265	300	335	350	405
3	235	270	300	315	340	390
Total	17610	18645	22370	21135	20910	26440
Ave.	244.5	258.9	310.6	293.5	290.4	367.2

3. Rising + Broken

	First Syllable			Second Syllable	
	onset	2/3	end	onset	end
zÁu mŭ					
1	240	255	315	295	320
2	255	250	310	290	330
3	250	245	300	280	330
zÁu ŋĂ					
1	225	260	310	300	390
2	250	255	310	300	385
3	250	255	300	275	370
dÁp vă					
1	215	225	290	260	360
2	240	240	280	260	330
3	240	270	290	250	350

	First Syllable			Second Syllable	
	onset	2/3	end	onset	end
dÁp lĭ					
1	225	260	275	250	350
2	265	280	330	240	365
3	265	290	330	245	330
dán mĭa					
1	205	265	305	300	425
2	240	265	295	290	390
3	215	260	320	270	380
dÁu vĭ					
1	215	230	290	275	370
2	225	245	280	270	340
3	230	240	280	265	345

	First Syllable			Second Syllable	
	onset	2/3	end	onset	end
zÂu ŋTe					
1	220	225	310	280	380
2	250	235	315	290	375
3	250	235	290	280	360
kán zĕ					
1	225	220	280	260	380
2	250	240	330	270	360
3	235	230	310	270	360
Total	5680	5975	7245	6565	8675
Ave.	236.6	248.9	301.8	273.5	361.4

4. Rising + Falling

	First Syllable			Second Syllable		
	onset	2/3	end	onset	mid	end
bát dân						
1	240	270	390	225	215	205
2	230	250	360	215	205	200
3	225	240	350	205	205	190
bÁt dôŋ						
1	230	270	390	230	220	210
2	230	250	360	220	215	200
3	220	250	370	225	210	200
bđi zà						
1	200	220	315	250	200	190
2	195	210	275	240	210	180
3	190	215	240	215	190	170
bán dă						
1	210	220	255	240	220	200
2	205	210	240	240	200	190
3	195	200	220	230	195	190
bđi bÀi						
1	220	235	330	265	225	195
2	205	230	310	250	215	190
3	205	220	300	240	205	190
bđŋ bên						
1	215	220	290	260	230	195
2	205	210	270	240	220	195
3	200	205	260	235	210	195

	First Syllable			Second Syllable		
	onset	2/3	end	onset	mid	end
bđt làl						
1	240	290	370	230	220	205
2	220	270	390	225	215	195
3	220	280	390	215	210	185
dÁ mÀl						
1	215	215	300	280	235	195
2	205	215	290	270	220	190
3	200	205	270	265	220	190
dÁp zàl						
1	215	220	250	250	220	200
2	200	200	260	245	210	200
3	185	195	300	230	205	190
dán gàn						
1	205	215	280	270	235	220
2	195	205	260	245	230	220
3	205	205	240	245	220	195
dđn dÀu						
1	215	215	260	260	230	205
2	205	210	260	245	205	190
3	200	200	240	240	205	180
dÁl zÀm						
1	215	215	270	270	240	200
2	200	205	265	250	210	210
3	195	195	235	240	200	200

	First Syllable			Second Syllable		
	onset	2/3	end	onset	mid	end
dÁp dân						
1	215	215	290	270	235	210
2	205	205	250	255	215	190
3	195	205	240	230	215	185
zđ ldo						
1	225	220	285	260	225	195
2	210	215	270	230	210	190
3	205	215	255	240	210	185
zđŋ nâl						
1	215	240	300	265	240	210
2	210	230	290	260	230	205
3	210	230	285	270	220	185
ldk nÂu						
1	210	230	360	240	220	195
2	210	230	285	225	205	170
3	210	230	300	235	205	180
mđl dÀu						
1	210	250	300	270	235	200
2	215	235	295	255	220	190
3	200	220	275	250	215	200
pÁt lÀ						
1	205	240	380	225	215	180
2	220	250	330	215	210	185
3	210	240	290	210	185	170
Total	11335	12180	15935	13105	11630	10480
Ave.	209.9	225.5	295.0	242.6	215.3	194.0

5. Rising + Curve

	First Syllable			Second Syllable		
	onset	2/3	end	onset	2/3	end
Aă Ăp						
1	220	240	295	255	175	170
2	210	235	295	240	170	165
3	195	225	280	240	150	150
bÁk bă						
1	230	290	350	220	135	135
2	225	270	325	205	120	120
3	220	275	315	210	150	150
bát bĕ						
1	245	290	420	210	170	140
2	245	290	375	195	160	140
3	230	280	335	190	160	135
dÁp bĕ						
1	205	240	305	230	190	145
2	190	215	266	240	200	150
3	190	230	270	230	175	115

	First Syllable			Second Syllable		
	onset	2/3	end	onset	2/3	end
dÁp bĕ						
1	205	220	290	235	155	155
2	190	210	280	250	140	140
3	185	220	265	230	135	135
dÁp dĕl						
1	200	220	275	260	160	180
2	180	220	265	255	165	200
3	180	210	265	240	150	190
dÂu dĕ						
1	200	205	305	275	140	180
2	195	210	255	260	155	155
3	195	205	265	235	155	165
dđŋ vĕl						
1	210	210	300	265	165	170
2	205	210	290	235	165	180
3	205	210	275	230	160	175

	First Syllable			Second Syllable		
	onset	2/3	end	onset	2/3	end
zđl bÂn						
1	205	225	295	260	150	150
2	195	235	280	225	150	150
3	195	215	265	225	145	175
bđk dÂu						
1	240	275	370	225	145	175
2	235	280	330	205	160	175
3	245	285	325	225	155	165
Total	6270	7145	9026	7000	4705	4730
Ave.	209.0	238.1	300.8	233.3	156.8	157.6

6. Rising + Drop

	First Syllable			Second Syllable		
	onset	2/3	end	onset	2/3	end
báv vĩet						
1	250	290	370	245	235	?
2	255	290	350	245	230	?
3	245	255	320	235	225	?
bát buõk						
1	260	315	395	240	235	?
2	235	270	385	235	225	?
3	250	264	390	235	220	?
bát zíet						
1	250	300	430	245	230	?
2	240	295	365	230	220	?
3	250	290	330	225	215	?

	First Syllable			Second Syllable		
	onset	2/3	end	onset	2/3	end
dÃn vÃt						
1	225	220	280	260	235	?
2	215	215	255	265	225	?
3	205	215	240	255	215	?
dÃn zãk						
1	220	225	265	275	230	?
2	220	230	260	260	220	?
3	215	210	275	255	210	?
zdŋ vÃt						
1	225	225	290	260	225	?
2	215	215	280	245	215	?
3	225	225	265	230	220	?

	First Syllable			Second Syllable		
	onset	2/3	end	onset	2/3	end
zdp vĩek						
1	220	270	330	230	225	?
2	220	250	310	230	225	?
3	210	240	290	215	210	?
!ãi vã						
1	210	235	300	270	230	?
2	210	230	290	250	225	?
3	205	220	280	245	220	?
mãi !Ãn						
1	230	255	315	290	250	?
2	215	235	315	270	250	?
3	210	220	305	270	245	?
Total	6130	6704	8480	6710	6110	
Ave.	227.0	248.2	314.0	248.5	226.2	

c. BROKEN + OTHER COMBINATIONS

1. Broken + Level

	First Syllable		Second Syllable		
	onset	end	onset	mid	end
bãe Xn					
1	250		310	320	310
2	250	320	305	310	305
3	230	310	300	305	305
bãe nXi					
1	240	280	290	290	295
2	230	300	290	295	290
3	215	280	285	285	285
bãe nXi					
1	-	-	300	300	300
2	235	300	305	300	300
3	225	290	290	285	290
zã ŋX					
1	-	-	310	290	290
2	235	270	290	295	285
3	220	270	290	285	280
gã zX…					
1	-	-	275	280	265
2	210	285	270	280	270
3	210	280	265	270	260

	First Syllable		Second Syllable		
	onset	end	onset	mid	end
!Ãq zÃ					
1	-	305	280	280	285
2	230	310	280	290	280
3	225	300	275	280	280
!Ãq pXn					
1	240	315	315	315	315
2	245	305	320	315	315
3	230	295	305	310	310
!Ãn pXn					
1	235	305	305	310	300
2	240	295	305	310	305
3	230	290	305	305	295
!ã Xm					
1	-	290	315	320	320
2	210	300	295	300	315
3	240	300	320	315	315
ŋX bX					
1	230	280	275	285	285
2	230	285	270	275	275
3	240	280	265	275	270

	First Syllable		Second Syllable		
	onset	end	onset	mid	end
ŋÃ !Xn					
1	230	295	290	295	290
2	235	285	285	285	285
3	220	265	275	285	285
ŋã Xm					
1	240	315	315	315	315
2	220	280	295	300	300
3	220	-	275	285	280
zÃ mXn					
1	250	295	295	300	300
2	240	275	295	295	290
3	250	270	285	285	280
mÃi zXe					
1	230	310	290	290	290
2	230	290	290	290	290
3	210	270	280	280	290
Total	8550	11110	12275	12400	12280
Ave.	231.8	292.3	292.2	295.2	292.3

2. Broken + Rising

	First Syllable		Second Syllable		
	onset	end	onset	2/3	end
bXu zŝ					
1			250	235	350
2	235	300	240	235	340
3	230	285	240	230	290
bXu zét					
1	240	300	285	330	410
2	235	300	305	330	375
3	235	305	305	320	390
!Ãn zÃu					
1		265	250	370	
2	240	280	265	240	360
3	245	270	240	235	350

	First Syllable		Second Syllable		
	onset	end	onset	2/3	end
!Xu zÃu					
1			245	230	370
2	230	310	245	240	360
3	225	290	245	230	340
mXu zÃu					
1		290	260	235	360
2	225	280	250	230	340
3	220	270	240	225	320
vã dÃn					
1	220	260	245	235	360
2	230	250	240	230	360
3	225	270	235	230	320

	First Syllable		Second Syllable		
	onset	end	onset	2/3	end
!ã bÃi					
1			240	235	345
2	220	280	245	235	335
3	210	250	230	230	335
Total	3665	4790	5315	5190	7380
Ave.	229.0	281.7	253.0	247.1	351.4

3. Broken + Broken

	First Syllable		Second Syllable	
	onset	end	onset	end
˥˩˧ mɪ̆u				
1	240	320	280	350
2	240	315	280	400
3	245	310	265	360
mɪ̆˥ mɪ̆˥				
1		290	290	370
2	250	300	285	360
3	250	310	290	
bɜ̆ ŋɜ̆				
1			265	440
2	240	300	265	400
3	225	300	260	360
zɜ̆ zɪ̆˥				
1	250	330	290	340
2	255	310	285	360
3	245	300	270	340
zʊ̈ŋ mɪ̆p				
1		300	290	380
2	240	300	290	410
3	230	300	295	400

	First Syllable		Second Syllable	
	onset	end	onset	end
˥˩ŋ dɪ̆ŋ				
1			315	410
2	250	315	285	420
3	260	380	290	
˥ɜ̆ŋ pɜ̆ŋ				
1	250	320	305	470
2	255	310	300	440
3	255	320	300	430
˥˩n bɪ̆n				
1		300	290	420
2	240	310	290	450
3	230	290	285	430
˥˩n bɜ̆n				
1	240	290	280	430
2	235	300	265	420
3	240	300	250	
˥ɜ̆ mɪ̆ŋ				
1	235	290	290	430
2	245	300	280	390
3	245	300	290	

	First Syllable		Second Syllable	
	onset	end	onset	end
˥˩n mɜ̆n				
1			310	510
2	260	350	310	470
3	250	325	295	
pʊ̈ŋ pɜ̆ŋ				
1	240	320	290	410
2	235	320	290	420
3	245	310	280	
vɜ̆ zʊ̈ŋ				
1	230	310	255	410
2	240	320	260	430
3	230	310	250	
vʊ̈ bɪ̆u				
1	220	270	270	380
2	220	270	265	360
3	230	270	240	
Total	8690	11905	11829	113800
Ave.	241.3	305.2	291.6	405.8

4. Broken + Falling

	First Syllable		Second Syllable		
	onset	end	onset	mid	end
zʊ̈n dɪ̆u					
1			260	225	205
2			250	210	190
3			240	205	185
zʊ̈ zɪ̆ŋ					
1	215		245	220	180
2			240	210	190
3			225	195	180
zʊ̈ŋ zɪ̆					
1		320	245	215	175
2	205	300	245	215	180
3	205	290	230	195	165
˥˩u bɪ̆					
1			240	215	185
2	205		235	210	175
3			235	205	175
˥˩˥ ˥˩n					
1		330	255	225	190
2	210	305	255	220	180
3	195	285	240	210	180

	First Syllable		Second Syllable		
	onset	end	onset	mid	end
ŋɪ̆ ˥ŋ					
1			290	250	220	195
2	220		285	245	210	185
3	200		270	240	210	185
vʊ̈ dɪ̆u						
1				245	215	180
2	200		280	240	210	180
3	190		265	235	210	190
vɜ̆ dɪ̆˥						
1	200		280	255	215	200
2	200		275	240	210	185
3	210		260	230	190	180
vɜ̆ŋ bɪ̆n						
1			270	240	220	200
2	200		270	240	210	195
3	190		260	230	210	185
zɜ̆ zɪ̆p						
1	215		290	260	225	190
2	210		280	255	215	185
3	205		280	240	210	180

	First Syllable		Second Syllable		
	onset	end	onset	mid	end
˥˩˥ dɪ̆˥					
1		310	240	215	195
2	205	280	235	210	185
3	195		220	190	180
mɪ̆ ŋʊ̈˥					
1	225	300	255	225	205
2	210	275	255	230	200
3		270	240	205	190
pɜ̆ mɪ̆n					
1		280	250	220	190
2	220	265	245	220	185
3	195	260	230	210	180
vʊ̈ vɪ̆					
1		300	245	220	175
2	210	275	245	205	185
3	200	250	235	205	175
Total	5335	8750	10180	8910	7795
Ave.	205.1	282.2	242.3	212.1	185.5

6. Broken + Drop

	First Syllable		Second Syllable		
	onset	end	onset	2/3	end
zɪ̆n zʊ̈					
1	240	300	265	245	?
2	235	280	255	250	?
3	230	290	245	225	?
zɪ̆n dɪ̆u					
1		280	285	220	?
2	230	270	265	215	?
3	220	280	260	200	?
dɜ̆ dɪ̆t					
1		320	255	205	?
2	215	300	255	210	?
3	200	280	240	190	?
˥˩ŋ mɪ̆n					
1		310	270	215	?
2	215	290	270	230	?
3	225	300	265	205	?
˥˩p dɪ̆u					
1	230	270	265	210	?
2	205	270	255	225	?
3	200	270	250	200	?
˥ɜ̆ dɜ̆					
1	220	270	240	210	?
2	220	270	235	210	?
3	205	270	235	210	?

	First Syllable		Second Syllable		
	onset	end	onset	2/3	end
mɜ̆˥ mɪ̆˥					
1	220	300	250	225	?
2	210	305	240	195	?
3	200	320	240	200	?
mʊ̈ zɪ̆					
1		280	260	200	?
2	215	270	255	205	?
3	200	255	245	200	?
pɪ̆n ˥ɪ̆					
1		290	260	210	?
2	215	290	255	215	?
3	210	280	245	215	?
vɜ̆ nɪ̆					
1	225	300	265	225	?
2	215	305	260	220	?
3	215	310	270	210	?
vɪ̆n mɜ̆p					
1	220	280	255	220	?
2	215	280	250	210	?
3	210	280	245	220	?
Total	6080	9175	8405	7045	
Ave.	216.4	286.7	254.7	213.4	

5. Broken + Curve

	First Syllable		Second Syllable		
	onset	end	onset	2/3	end
dɜ̆ dɪ̆					
1	235	300	250	160	160
2	215	340	245	155	155
3	225	280	250	155	155
ŋʊ̈ bɪ̆˥					
1	230	280	245	150	150
2	225	280	240	170	170
3	205	260	230	150	150
Total	1335	1740	1460	940	940
Ave.	222.5	290.0	243.3	156.6	156.6

d. FALLING + OTHER COMBINATIONS

1. Falling + Level

	First Syllable			Second Syllable		
	onset	mid	end	onset	mid	end
vÂŋ Ẑn						
1	225	225	225	265	280	280
2	225	225	220	270	275	275
3	220	220	220	260	260	270
zàŋ ẓÃi						
1	230	225	220	245	270	275
2	225	225	220	240	265	270
3	225	225	220	245	260	270
dÂu zẊn						
1	240	245	245	275	300	295
2	235	250	235	270	285	280
3	235	240	230	260	260	260
gài nẄm						
1	225	245	245	250	310	280
2	230	235	240	240	270	280
3	215	240	230	240	280	270
tÂm Ẅn						
1	225	220	225	255	275	270
2	225	220	220	255	265	265
3	220	220	220	240	260	255
mè nẼu						
1	225	235	230	240	275	270
2	230	230	225	240	265	270
3	225	225	230	235	260	255
gài dẄm						
1	230	230	225	240	265	270
2	230	235	220	235	255	260
3	220	220	215	235	255	260

	First Syllable			Second Syllable		
	onset	mid	end	onset	mid	end
bÂn Ẅn						
1	230	230	230	285	290	295
2	225	230	220	275	280	280
3	230	225	220	260	265	270
bàŋ nẄu						
1	235	230	225	265	285	285
2	235	230	225	255	270	270
3	225	220	215	240	255	260
zÂu Ẅn						
1	235	220	220	260	275	260
2	225	220	220	255	260	255
3	210	205	205	240	255	250
dÂu duẄl						
1	225	230	225	235	285	275
2	220	225	220	240	270	270
3	210	220	215	235	270	265
tÂm Ẅn						
1	225	225	220	275	275	275
2	225	225	220	265	265	265
3	220	220	220	255	265	265
mùA dẄŋ						
1	220	220	220	250	275	275
2	210	215	220	250	260	260
3	210	210	210	240	260	245
dÂn Ẅŋ						
1	230	225	220	270	270	260
2	215	215	220	265	265	255
3	215	215	210	240	245	245

	First Syllable			Second Syllable		
	onset	mid	end	onset	mid	end
dÀu dẄn						
1	225	225	225	240	270	280
2	215	225	225	245	280	280
3	215	220	215	240	270	270
dèn Ẅn						
1	235	230	225	260	265	265
2	215	220	220	255	260	260
3	215	215	215	245	250	250
dò ŋẊŋ						
1	215	225	215	245	265	270
2	215	220	210	235	245	250
3	210	210	210	230	240	245
dò Ẅn						
1	220	220	220	270	270	270
2	215	220	220	265	270	260
3	210	215	215	255	255	255
dòŋ nẊm						
1	230	230	220	245	270	265
2	215	220	215	245	265	265
3	215	210	205	230	250	250
tÂm zẼu						
1	225	220	220	250	270	265
2	215	215	220	245	260	260
3	205	205	205	240	255	245
pÅ nẄ						
1	230	230	230	245	275	270
2	225	225	225	240	270	260
3	225	220	225	235	260	260
Total	14025	14110	13940	15750	16845	16755
Ave.	222.6	223.9	221.2	250.0	267.3	265.9

2. Falling + Rising

	First Syllable			Second Syllable		
	onset	mid	end	onset	2/3	end
bÅ tấn						
1	215	210	205	205	210	300
2	215	210	200	200	200	290
3	205	205	200	195	205	270
bÂn gổ						
1	210	205	205	210	210	330
2	205	205	205	205	210	295
3	215	205	205	195	205	295
bồŋ bé						
1	195	205	200	205	215	320
2	200	200	200	195	215	300
3	190	185	185	195	200	255
bè bấn						
1	195	210	205	205	210	300
2	200	205	200	195	200	290
3	200	200	200	195	205	290
bùoŋ zấl						
1	205	210	205	210	205	295
2	200	200	195	205	210	320
3	200	200	200	205	200	280
dâu gổl						
1	205	205	200	190	200	310
2	210	205	205	195	200	300
3	205	205	205	195	195	300
dân gẤp						
1	210	220	205	205	200	290
2	215	215	210	215	210	300
3	200	200	200	200	205	290

	First Syllable			Second Syllable		
	onset	mid	end	onset	2/3	end
gÅ mẮl						
1	210	210	200	195	190	295
2	205	205	195	195	200	280
3	200	205	200	195	195	260
gài ổm						
1	215	210	205	195	210	370
2	210	210	205	190	210	290
3	200	205	195	185	200	260
dÂn Ấp						
1	215	215	215	240	285	370
2	210	210	190	225	265	360
3	205	205	205	225	265	350
dầm Ấm						
1	210	210	205	210	215	340
2	215	215	205	205	215	310
3	210	205	195	205	215	280
dồŋ bổŋ						
1	210	215	205	215	210	330
2	220	210	205	205	210	290
3	200	205	195	205	200	270
zà zẮk						
1	220	210	205	210	205	310
2	205	205	200	250	280	340
3	210	205	205	250	275	350
tÂm zẮŋ						
1	205	205	205	205	200	300
2	215	210	205	205	205	305
3	195	195	195	195	195	290

	First Syllable			Second Syllable		
	onset	mid	end	onset	2/3	end
tÂn zẮ						
1	205	205	200	205	205	290
2	210	210	205	200	210	270
3	210	205	200	200	200	260
tà tối						
1	215	215	210	205	230	305
2	215	210	200	205	215	335
3	210	200	200	190	200	265
tà dấk						
1	205	205	205	235	270	370
2	205	215	200	235	270	350
3	195	190	195	225	260	310
mÂn ẩk						
1	215	215	210	215	270	340
2	220	215	205	225	270	320
3	215	210	205	230	265	330
mà Ấm						
1	215	215	205	205	210	270
2	210	210	205	205	215	300
3	205	205	205	210	210	290
nân nấp						
1	215	215	205	225	260	355
2	210	210	205	225	265	360
3	200	200	200	215	250	320
vÂŋ tẮ						
1	215	210	205	205	205	255
2	215	205	195	205	205	270
3	205	200	195	195	195	235
Total	13090	13035	12725	13090	13915	19150
Ave.	207.7	206.9	201.9	207.7	220.8	304.5

3. Falling + Broken

	First Syllable			Second Syllable	
	onset	mid	end	onset	end
bÅ tÃu					
1	225	220	210	210	360
2	215	215	210	210	340
3	215	215	210	210	330
zǒi tš					
1	230	235	220	215	380
2	225	235	220	215	380
3	220	225	220	215	370
gÅi bāi					
1	225	230	220	215	370
2	225	230	210	210	380
3	225	225	220	215	380
tǒi t3m					
1	220	225	215	220	360
2	220	225	210	215	350
3	210	210	210	215	370
nÅn zǒi					
1	220	220	215	220	340
2	220	215	210	215	330
3	225	215	210	210	330

	First Syllable			Second Syllable	
	onset	mid	end	onset	end
ŋǎi zš					
1	220	220	210	230	340
2	230	225	220	215	330
3	220	220	220	225	350
ɲǎm pš					
1	225	225	220	215	370
2	225	225	220	225	350
3	220	210	215	210	340
bǎi vɛ̄					
1	220	220	210	220	350
2	210	215	205	225	340
3	205	210	200	215	350
zǎŋ zǎi					
1	225	215	215	220	350
2	230	215	210	215	320
3	230	210	210	215	330
dÅu ŋš					
1	220	215	215	215	360
2	210	215	215	215	360
3	205	210	205	215	330

	First Syllable			Second Syllable	
	onset	mid	end	onset	end
dǎŋ tuÃ					
1	215	220	210	220	330
2	210	215	210	215	330
3	205	200	200	210	340
zÅ tÃu					
1	220	225	220	225	370
2	225	225	225	225	360
3	225	215	215	215	330
mǎn pūn					
1	230	230	225	225	390
2	215	225	215	220	360
3	220	215	215	215	390
vùŋ vāi					
1	220	225	215	225	340
2	215	225	220	225	360
3	210	215	215	215	350
Total	9225	9031	8983	9120	14790
Ave.	219.6	215.0	213.9	217.1	352.1

4. Falling + Falling

	First Syllable			Second Syllable		
	onset	mid	end	onset	mid	end
zÅu zǎo						
1	235	230	215	210	205	165
2	215	215	195	200	205	165
3	205	205	180	200	190	155
dÅu bǎ						
1	215	220	215	205	210	185
2	195	205	205	195	200	165
3	195	195	195	195	190	165
hīən tÃn						
1	220	205	195	205	200	170
2	210	205	200	205	190	170
3	205	200	190	195	195	160
tÃn zÅu						
1	205	205	205	215	215	200
2	200	200	200	200	205	185
3	195	195	195	200	195	180
mǎ tuÃ						
1	210	225	215	215	205	175
2	210	210	205	205	190	175
3	205	205	205	205	195	165
ŋÅ ŋÃ						
1	215	220	210	210	200	185
2	220	215	205	205	200	180
3	200	205	200	200	195	160

	First Syllable			Second Syllable		
	onset	mid	end	onset	mid	end
ŋǎi zǎi						
1	220	225	220	210	215	185
2	195	220	205	205	210	175
3	190	205	195	205	205	165
mÃn mÃn						
1	210	215	210	200	205	200
2	200	210	200	200	195	175
3	205	205	185	195	190	165
Aǎ Aǎ						
1	215	220	205	220	210	195
2	220	220	205	210	215	200
3	200	210	200	210	205	185
zǎn zǎn						
1	225	225	215	215	210	180
2	215	215	210	215	210	165
3	210	215	210	205	205	195
dÅu dǎ						
1	210	210	205	205	205	175
2	195	205	200	200	200	175
3	190	200	195	185	195	175
hÃŋ zÅu						
1	225	215	205	215	210	195
2	205	205	195	210	205	185
3	190	195	190	205	200	180

	First Syllable			Second Syllable		
	onset	mid	end	onset	mid	end
tÃu pǎu						
1	210	210	210	210	205	180
2	200	205	205	205	190	180
3	195	190	190	190	180	180
tǎ mǎ						
1	210	210	210	205	205	180
2	195	200	200	200	195	180
3	190	195	190	185	185	165
tǎi ɕuīən						
1	215	215	205	205	210	180
2	200	205	200	200	200	175
3	190	200	195	190	190	175
vēu vēu						
1	215	210	210	210	205	185
2	195	200	200	195	190	180
3	185	190	190	190	180	170
Total	9875	10005	9685	9760	9610	8330
Ave.	205.7	208.4	201.7	203.3	200.2	173.5

5. Falling + Curve

	First Syllable			Second Syllable		
	onset	mid	end	onset	2/3	end
dǎŋ dÃŋ						
1	215	230	215	205	160	160
2	215	230	215	205	150	150
3	215	220	215	200	145	145
tÃn zǎ						
1	215	225	225	205	170	170
2	205	215	215	200	160	160
3	210	215	215	195	160	160

	First Syllable			Second Syllable		
	onset	mid	end	onset	2/3	end
mǎn mǎŋ						
1	220	215	200	205	180	180
2	205	210	210	195	165	165
3	205	205	205	190	165	165
mǎn mǎi						
1	215	215	215	195	145	175
2	195	205	205	185	145	160
3	185	195	195	175	150	185

	First Syllable			Second Syllable		
	onset	mid	end	onset	2/3	end
mǎ mÃ						
1	215	225	220	215	160	160
2	210	230	220	205	145	145
3	185	205	210	205	145	145
ŋǎi tĒ						
1	205	215	205	210	155	155
2	205	215	210	195	155	155
3	210	205	205	200	160	160
Total	3730	3875	3800	3585	2815	2915
Ave.	207.2	215.2	211.1	199.1	156.3	161.9

6. Falling + Drop

	First Syllable			Second Syllable		
	onset	mid	end	onset	2/3	end
bÂn tw̃at						
1	230	240	235	225	230	?
2	225	230	215	220	220	?
3	210	230	220	210	215	?
zÂu tÃn						
1	230	220	210	220	215	?
2	225	220	205	215	215	?
3	210	215	210	205	210	?
tÂn dÃu						
1	215	220	215	215	215	?
2	210	215	210	205	200	?
3	205	210	210	195	200	?
dẽŋ bÃk						
1	225	225	220	215	215	?
2	205	220	200	205	205	?
3	195	215	205	200	195	?
dẽŋ gi᷄ap						
1	215	220	215	215	215	?
2	200	205	200	205	210	?
3	200	205	200	200	200	?
zẽŋ zɜ̃t						
1	215	215	205	205	205	?
2	205	205	195	200	200	?
3	195	195	185	185	185	?
tÂm bõ						
1	205	210	205	210	210	?
2	205	205	205	200	205	?
3	200	200	200	200	200	?

	First Syllable			Second Syllable		
	onset	mid	end	onset	2/3	end
tÂp tÃn						
1	215	220	210	210	205	?
2	210	220	205	205	210	?
3	205	210	205	205	200	?
tÂn mÃp						
1	215	210	210	210	210	?
2	210	215	210	205	205	?
3	205	215	205	205	195	?
tÂm tõn						
1	215	220	210	210	210	?
2	215	215	205	205	205	?
3	210	210	210	200	200	?
tõ tõn						
1	210	215	205	205	205	?
2	210	210	210	205	200	?
3	205	205	205	205	205	?
dÂm tw̃n						
1	220	220	220	215	215	?
2	215	215	215	215	215	?
3	205	210	210	210	215	?
dẽ dÃt						
1	215	220	215	215	205	?
2	205	215	205	200	200	?
3	200	205	200	200	190	?
dẽu dãn						
1	215	215	215	215	210	?
2	210	215	210	210	210	?
3	205	205	205	205	205	?

	First Syllable			Second Syllable		
	onset	mid	end	onset	2/3	end
dẽ dÃn						
1	215	220	210	210	205	?
2	205	215	210	205	200	?
3	195	205	200	200	200	?
zÂ zÃn						
1	215	210	215	220	215	?
2	210	210	210	210	210	?
3	210	200	200	200	195	?
zà! dÃp						
1	205	200	200	200	195	?
2	200	205	195	195	190	?
3	195	200	190	200	190	?
tuẽ tw̃t						
1	225	220	210	215	210	?
2	210	210	205	205	210	?
3	210	205	200	200	200	?
tẽ tã						
1	225	230	215	215	215	?
2	220	220	205	205	205	?
3	210	215	205	205	195	?
Total	11990	12170	11840	11790	11715	
Ave.	210.3	213.5	207.7	206.8	205.5	

e. CURVE + OTHER COMBINATIONS

1. Curve + Level

	First Syllable			Second Syllable		
	onset	2/3	end	onset	mid	end
bÂn tÃ!						
1	190	165	165	225	285	275
2	190	165	165	235	260	270
3	175	165	165	200	235	245
bÂŋ dẼn						
1	205	165	165	220	260	275
2	205	160	160	210	250	260
3	190	150	150	215	255	250
bÂu Xn						
1	195	180	170	255	280	280
2	195	165	145	225	240	275
3	200	170	160	225	260	260
bẽ bẼ!						
1	215	180	175	225	275	285
2	195	170	170	210	255	275
3	190	170	160	210	250	265
bẽ vẼ!						
1	195	170	165	230	295	290
2	190	170	160	240	275	275
3	175	155	155	230	270	265
bẽ tXn						
1	190	170	160	255	270	270
2	190	160	155	240	270	265
3	175	155	145	230	255	260

	First Syllable			Second Syllable		
	onset	2/3	end	onset	mid	end
dõ Xn						
1	205	180	165	275	275	295
2	195	170	160	275	275	285
3	195	170	160	230	265	270
tÃ tẼ!						
1	210	165	185	235	280	290
2	200	165	165	235	270	280
3	195	170	165	215	235	250
mõ nXu						
1	200	165	165	230	255	265
2	195	155	160	220	255	255
3	180	155	165	215	245	245
mõŋ mẼ!						
1	190	165	165	220	275	280
2	205	160	160	215	265	280
3	195	155	155	205	265	265
gõ mẼ						
1	190	175	175	245	275	270
2	195	160	160	225	260	265
3	180	160	160	220	245	245
nõ nXu						
1	195	160	160	235	265	270
2	190	150	150	220	260	265
3	185	155	155	205	235	235

	First Syllable			Second Syllable		
	onset	2/3	end	onset	mid	end
mõ mXŋ						
1	200	185	170	240	295	295
2	200	175	165	235	260	270
3	190	170	160	215	250	250
gÂn gẼ						
1	205	190	180	225	265	270
2	210	190	175	220	265	265
3	190	180	165	235	255	250
gõn gXŋ						
1	195	180	170	225	265	275
2	195	180	165	220	250	270
3	190	180	165	195	250	250
nõ nXn						
1	200	165	170	220	250	250
2	195	150	160	210	240	235
3	200	155	165	215	240	230
pãp pẼ						
1	215	170	170	220	265	265
2	190	170	160	220	255	260
3	185	170	165	215	250	245
vẼ vXŋ						
1	185	160	160	205	250	250
2	195	160	170	210	245	250
3	195	155	155	205	235	235
Total	10495	9085	8720	12130	14045	14165
Ave.	194.3	166.7	161.4	224.6	260.0	262.3

2. Curve + Rising

	First Syllable			Second Syllable		
	onset	2/3	end	onset	2/3	end
bÉ tÁt						
1	195	165	165	190	195	300
2	200	155	155	185	205	295
3	180	140	140	180	200	285
bš Át						
1	195	145	145	195	200	300
2	185	155	155	190	215	315
3	180	140	140	185	205	315
bš bÁn						
1	180	165	165	185	195	315
2	175	165	165	180	195	310
3	180	155	155	180	185	265
dš mÁu						
1				190	205	320
2	180	145	145	185	205	310
3	160	160	160	170	190	260

	First Syllable			Second Syllable		
	onset	2/3	end	onset	2/3	end
zÄ zót						
1				185	230	305
2	180	145	145	185	220	295
3	175	150	150	180	200	260
zÄt dÁp						
1	215	165	165	200	250	340
2	210	155	155	205	260	365
3	205	145	145	195	240	330
tÄn ndp						
1	200	185	185	215	275	380
2	195	170	170	195	250	350
3	190	165	165	195	245	310
pš bé						
1		150	150	175	200	315
2	185	155	155	175	185	280
3	180	155	155	170	175	255

	First Syllable			Second Syllable		
	onset	2/3	end	onset	2/3	end
pät adø						
1		170	170	190	210	325
2	200	165	165	180	200	330
3	210	165	165	180	195	270
zÄt zÄk						
1				240	290	345
2	195	145	145	210	255	325
3	190	130	130	215	255	305
Total	4740	4205	4205	5705	6530	9275
Ave.	189.6	155.7	155.7	190.1	217.6	309.1

3. Curve + Broken

	First Syllable			Second Syllable	
	onset	2/3	end	onset	end
bÉ gÄt					
1	195	165	165	195	330
2	195	155	155	195	320
3	185	155	155	185	320
qÄ mÜ					
1	200	165	170	195	400
2	185	155	170	200	400
3	190	155	160	195	360

	First Syllable			Second Syllable	
	onset	2/3	end	onset	end
nš zš					
1	190	170	165	205	330
2	200	170	160	205	350
3	170	160	155	195	
Aš nÄu					
1	210	170	170	200	330
2	195	155	165	190	320
3	180	155	155	185	

	First Syllable			Second Syllable	
	onset	2/3	end	onset	end
bš bÄn					
1	190	150	150	180	360
2	185	150	150	200	330
3	170	150	150	190	320
bät tÉ					
1	190	170	170	200	340
2	185	160	160	185	330
3	185	155	155	175	330
Total	3400	2885	2880	3475	5470
Ave.	188.8	159.1	160.0	193.0	341.8

4. Curve + Falling

	First Syllable			Second Syllable		
	onset	2/3	end	onset	mid	end
bÄn dð						
1	205	180	155	205	220	205
2	190	185	155	200	215	210
3	185	170	155	190	215	195
dš tàe						
1	185	175	165	200	220	195
2	190	180	160	190	205	185
3	180	165	165	185	200	175
dš zðŋ						
1	180	170	165	205	210	185
2	185	165	160	200	205	185
3	185	165	165	195	200	185
zÄ vð						
1				195	210	180
2	195	160	160	190	205	180
3	190	155	155	195	205	180

	First Syllable			Second Syllable		
	onset	2/3	end	onset	mid	end
zÄŋ dð						
1	185	165	170	200	205	190
2	185	185	145	190	190	175
3	180	180	155	190	190	170
mš mÄn						
1				185	200	190
2	180	170	160	185	190	180
3	180	160	160	180	185	170
nš dðŋ						
1	170	165	165	200	205	190
2	180	165	160	190	200	170
3	175	160	160	180	190	170
qš qät						
1	190	175	165	205	205	180
2	180	170	160	185	200	185
3	180	170	165	185	190	180

	First Syllable			Second Syllable		
	onset	2/3	end	onset	mid	end
š quÄt						
1	175	165	160	190	200	175
2	180	175	155	195	195	190
3	170	160	155	195	195	185
š pÄ						
1	180	175	170	200	200	165
2	185	175	165	195	195	180
3	170	165	165	185	185	175
zš zð						
1				185	205	175
2	195	155	165	195	200	175
3	185	145	150	190	190	165
Total	5495	5050	4810	6170	6625	5995
Ave.	183.1	168.3	160.3	192.8	207.0	187.3

5. Curve + Curve

	First Syllable			Second Syllable		
	onset	2/3	end	onset	2/3	end
dÃu zÃ						
1	195	170	170	190	145	170
2	185	160	160	185	145	165
3	175	140	145	175	145	155
Ãu Ãn						
1	210	170	180	225	160	180
2	205	165	170	200	160	165
3	175	150	165	180	140	170
Ãu dÃ						
1	185	165	175	180	145	195
2	185	160	160	180	155	190
3	170	155	155	165	135	160
bÃu dÃm						
1	180	140	165	175	150	170
2	175	135	170	175	150	180
3	170	125	150	175	140	175

	First Syllable			Second Syllable		
	onset	2/3	end	onset	2/3	end
bÃm bĒm						
1	180	160	170	180	155	185
2	180	165	170	180	160	185
3	165	145	150	175	150	180
bÃn zÃn						
1	195	160	165	195	155	205
2	175	170	170	200	155	195
3	170	155	155	175	155	190
dÃŋ duÃŋ						
1	190	165	165	180	150	195
2	185	165	165	180	160	180
3	180	160	160	165	150	180
zÃŋ zÃi						
1	205	170	190	200	140	145
2	205	160	180	190	155	145
3	190	155	165	185	145	165

	First Syllable			Second Syllable		
	onset	2/3	end	onset	2/3	end
ĺÃŋ vÃŋ						
1	195	150	165	190	145	170
2	190	160	180	185	150	185
3	185	145	165	175	145	170
ĺÃu dÃu						
1	190	160	175	180	145	180
2	180	160	160	180	150	180
3	175	130	170	175	155	180
ĺÃm bÃm						
1	185	170	170	185	160	195
2	180	160	170	195	155	200
3	185	155	155	165	155	200
ĺÃŋ ĺÃŋ						
1	195	170	170	200	155	165
2	175	160	160	185	155	180
3	170	165	165	185	150	180
Total	6635	5850	5975	6610	5420	6410
Ave.	184.3	156.9	165.9	183.6	150.5	178.0

6. Curve + Drop

	First Syllable			Second Syllable		
	onset	2/3	end	onset	2/3	end
zĒ zĒŋ						
1	205	175	175	215	215	?
2	205	170	170	210	210	?
3	200	165	165	200	205	?
zĒ mĒt						
1	190	160	160	200	200	?
2	190	160	160	200	195	?
3	185	165	165	195	185	?
vÃn dĒk						
1	190	180	180	185	200	?
2	195	170	170	190	195	?
3	185	160	160	185	195	?
Ãn zÃt						
1	190	170	170	205	205	?
2	180	165	165	200	195	?
3	190	165	165	195	185	?
bÃu vĒ						
1	200	175	175	200	200	?
2	190	165	165	195	200	?
3	185	165	165	195	200	?
bĪən ĺÃn						
1	185	180	170	205	210	?
2	185	175	170	200	205	?
3	185	180	165	190	195	?

	First Syllable			Second Syllable		
	onset	2/3	end	onset	2/3	end
bĒŋ ĺĒk						
1	185	170	160	200	200	?
2	185	165	160	195	190	?
3	185	165	155	185	185	?
bĒ pĺəu						
1	170	160	160	200	205	?
2	185	160	160	185	205	?
3	175	165	165	185	195	?
bĒ zūŋ						
1	180	175	175	205	205	?
2	190	165	165	205	205	?
3	195	175	175	190	200	?
dÃ dūŋ						
1	185	170	170	195	195	?
2	185	165	175	185	185	?
3	180	165	175	185	190	?
dÃŋ bĒ						
1	180	160	160	200	195	?
2	185	160	170	190	190	?
3	175	150	155	185	180	?
dÃu ĺūÃn						
1	175	165	165	190	205	?
2	180	155	160	190	200	?
3	170	145	155	190	185	?

	First Syllable			Second Syllable		
	onset	2/3	end	onset	2/3	end
dÃu ĺĒn						
1	195	175	170	190	200	?
2	185	165	170	195	195	?
3	175	165	165	195	185	?
zÃĺ dĒk						
1	180	155	155	190	190	?
2	175	165	165	185	185	?
3	180	150	150	180	180	?
vÃ ĺÃĺ						
1	185	170	175	195	200	?
2	185	170	170	185	195	?
3	180	155	165	180	185	?
vĒn vĒn						
1	195	170	170	190	200	?
2	190	165	165	190	195	?
3	195	160	160	195	195	?
Total	8920	7945	7955	9295	9415	
Ave.	185.8	165.5	165.7	193.6	196.1	

f. DROP + OTHER COMBINATIONS

1. Drop + Level

	First Syllable			Second Syllable		
	onset	2/3	end	onset	mid	end
bā̃n pX̄n						
1	22S	21S	?	24S	29O	29O
4	22S	21S	?	24S	29O	29O
5	22S	22S	?			
dÃ̄! zX̄n						
1	21S	21S	?	26S	29S	29S
2	21S	21S	?	25S	28S	28S
3	20O	20S	?	25S	28O	28O
dÃ̄! dX̄						
1	21S	21S	?	24S	27O	27O
2	22O	22O	?	24O	26S	26S
3	21S	21S	?	22S	25S	25S
dÃ̃u dX̄n						
1	22O	21O	?	26O	28S	28S
2	22O	22O	?	24O	26S	27O
3	21O	21O	?	24O	26S	26S
dX̄p zX̄!						
1	22O	21S	?	25O	28S	28O
2	21S	20S	?	25O	28O	27O
3	21S	20S	?	24O	27O	27O
dX̄ dX̄n						
1	22S	20S	?	25O	29S	28S
2	22S	22S	?	24S	27S	27S
3	22O	21S	?	23O	26S	26S
dX̄k X̄m						
1	21S	21S	?	28S	28S	28S
2	22O	21S	?	29O	29O	29O
3	22O	20S	?	27O	27O	27O

	First Syllable			Second Syllable		
	onset	2/3	end	onset	mid	end
dX̄! X̄n						
1				26S	28S	28S
2	22S	22S	?	26O	27O	27O
3	21S	21S	?	25O	26O	26O
dX̄ŋ vlX̄n						
1	22O	22O	?	25O	28S	28S
2	22S	21S	?	25S	28S	28S
3	21S	21S	?	25S	28O	28O
lX̄! vX̄n						
1	22S	22S	?	24S	28O	28O
2	21S	21S	?	24O	27S	28O
3	21S	21S	?	24S	27S	27S
nÃ̄n pX̄n						
1	22S	22S	?	25O	29O	29O
2	22O	22O	?	24S	28S	28S
3	22S	21S	?	23O	27S	27S
pÃ̄k plX̄n						
1	23O	22S	?	25S	28S	28S
2	22O	20O	?	26S	28S	28O
3	22O	21O	?	25S	27S	27S
zũ̃ot gX̄n						
1	22S	21S	?	23S	25S	25S
2	21S	21S	?	23O	25O	25O
3	21O	20S	?	22S	24O	24O
zũ̃k X̄p						
1	21O	21O	?	25S	27S	26S
2	21O	21O	?	24O	26O	26O
3	20S	20S	?	24O	25S	25S

	First Syllable			Second Syllable		
	onset	2/3	end	onset	mid	end
lX̄ŋ ŋX̄						
1				25S	28O	27O
2	23O	23O	?	25O	27S	26S
3	22S	22S	?	24S	25S	25S
lũ̃An zX̄n						
1	23S	23S	?	26S	29O	28O
2	22S	22S	?	26S	28S	28O
3	22O	22O	?	25O	26S	26S
zX̄ŋ dX̄ŋ						
1	23O	22O	?	24S	27O	27O
2	23O	23O	?	24O	27O	27O
3	22S	21O	?	23S	26S	26S
zX̄ŋ zX̄n						
1	22S	22S	?	26S	28S	28S
2	22S	22S	?	26S	27S	27S
3	22O	22O	?	25O	27S	27S
zlũ̃u vX̄ŋ						
1	23O	23O	?	23S	27O	27O
2	21S	21S	?	24O	26S	26S
3	21O	21O	?	24O	26O	26S
vX̄ lX̄!						
1	22S	22S	?	24S	28O	27S
2	22O	22O	?	24S	27S	28O
3	21S	21O	?	23S	27O	26S
Total	12755	12560		14685	16195	16130
Ave.	219.9	216.4		248.8	274.4	273.3

2. Drop + Rising

	First Syllable			Second Syllable		
	onset	2/3	end	onset	2/3	end
bÃ̄k Ák						
1	20S	22O	?	23S	27O	34S
2	20S	19S	?	22S	28O	32O
3	20O	19O	?	22O	25S	30O
bÃ̄k zÁ!						
1	21O	21S	?	21S	23O	32O
2	19S	20O	?	21S	22S	31O
3	19S	19S	?	20O	21O	28O
bã̄k ćk						
1	21O	21S	?	23O	30O	34O
2	22S	21S	?	23O	31O	34O
3	20S	21S	?	21O	26O	31O
bĩ Án						
1				22O	23S	36O
2	19O	19O	?	20O	23S	36O
3	20S	20S	?	20S	21O	30O
bõ̃ zÁŋ						
1				22O	22S	36S
2	20O	20O	?	21O	21S	34O
3	21O	21O	?	20S	21O	32O

	First Syllable			Second Syllable		
	onset	2/3	end	onset	2/3	end
bõ̃ mÁ!						
1	21O	20S	?	20S	21O	36O
2	21S	20S	?	20S	20S	35O
3	21O	20S	?	20S	21S	32S
dÃ̄! ðl						
1				23S	24S	32O
2	21S	22O	?	23S	24S	36S
3	21O	21S	?	20O	23O	32O
dÃ̃u zÁu						
1				22S	22S	35O
2	22S	23O	?	21S	21S	32O
3	22S	22S	?	20O	21O	32O
dõ̃ pÁ!						
1	22S	23O	?	21S	29S	45O
2	22S	22S	?	22O	27O	44O
3	21S	21S	?	22S	27S	46O
dõ̃k Ák						
1	21S	22S	?	22O	27S	36O
2	21O	21O	?	22S	27O	36O
3	21O	21O	?	22O	25O	33O

	First Syllable			Second Syllable		
	onset	2/3	end	onset	2/3	end
lÃ̄n bõ̃ot						
1				25O	29O	41S
2	22S	22S	?	23S	29O	38O
3	22O	20O	?	22O	28O	35O
lõ̃ Án						
1	22O	21S	?	22O	22O	29S
2	21S	21S	?	22O	22O	35O
3	20S	20S	?	20O	21O	31O
mÃ̄t bÃ̃u						
1	22O	22O	?	21O	22S	33O
2	21S	21S	?	21O	21S	33O
3	21S	21S	?	20S	22O	30O
qõ̃ zÁk						
1				24O	29S	41O
2	21O	21O	?	25S	30O	42O
3	21O	20O	?	25S	30O	38O
Total	7620	7605		9210	10360	14580
Ave.	211.6	211.2		219.2	246.6	347.1

3. Drop + Broken

	First Syllable			Second Syllable	
	onset	2/3	end	onset	end
bÃk dRl					
1	225	275	?	220	360
2	215	195	?	210	300
3	210	200	?	195	310
dÃm ɲR					
1	220	220	?	225	350
2	220	220	?	220	340
3	220	220	?	205	350
dÃu lRu					
1	215	215	?	205	360
2	210	210	?	205	340
3	210	200	?	205	300
dÃp vš					
1	215	215	?	210	360
2	220	220	?	200	360
3	215	210	?	190	360
pÃk mXu					
1	215	215	?	215	340
2	220	215	?	195	340
3	215	205	?	185	350
pÃk vš					
1	215	205	?	250	340
2	210	190	?	200	340
3	205	205	?	190	330
pÃn lšl					
1	205	205	?	215	340
2	225	225	?	205	330
3	210	210	?	205	330

	First Syllable			Second Syllable	
	onset	2/3	end	onset	end
pÃp ɳš					
1	220	210	?	210	360
2	215	205	?	205	330
3	210	195	?	190	340
bÃp b3m					
1	190	190	?	200	360
2	210	195	?	130	320
3	210	195	?	190	330
dÃp dš					
1				200	380
2	205	195	?	205	340
3	205	205	?	195	350
gÃ gXm					
1	205	205	?	210	320
2	205	195	?	195	310
3	210	195	?	200	320
gÃt gXm					
1				220	320
2	205	200	?	205	320
3	205	195	?	200	320
lÃk l3ɳ					
1	220	220	?	225	360
2	220	220	?	215	370
3	215	215	?	210	360
lÃn lšu					
1	235	235	?	220	340
2	210	210	?	210	330
3	210	210	?	205	340

	First Syllable			Second Syllable	
	onset	2/3	end	onset	end
lÃt lšu					
1	215	190	?	220	310
2	205	195	?	210	320
3	210	195	?	200	320
lõɳ lš					
1				215	330
2	215	215	?	210	310
3	215	215	?	200	310
l3k l3l					
1	220	210	?	205	360
2	225	205	?	205	330
3	210	205	?	195	340
lõɳ lšl					
1	215	215	?	225	350
2	215	215	?	220	340
3	210	210	?	215	330
mÃn lÃɳ					
1	225	225	?	225	360
2	210	210	?	220	350
3	215	215	?	215	330
mÃp mš					
1	220	220	?	225	370
2	225	225	?	215	340
3	210	210	?	205	330
ɳÃu ɳš					
1				235	340
2	220	220	?	225	340
3	220	220	?	220	330
Total	12620	12330		13145	21290
Ave.	213.9	208.9		208.6	337.9

4. Drop + Falling

	First Syllable			Second Syllable		
	onset	2/3	end	onset	mid	end
bÃk dÃu						
1				215	220	200
2	205	210	?	205	215	200
3	195	195	?	195	210	200
bÃn bš						
1				220	225	185
2	205	210	?	205	210	180
3	185	1 0	?	195	195	170
bÃn lÃɳ						
1	225	220	?	220	215	190
2	210	210	?	215	205	175
3	195	190	?	210	205	190
dÃl dÃɳ						
1	210	210	?	215	220	190
2	205	205	?	205	215	195
3	200	200	?	205	210	180
mũõn mÃɳ						
1				200	205	185
2	195	195	?	200	205	170
3	180	180	?	195	200	175
mÃp dõ						
1	205	205	?	205	205	180
2	200	200	?	195	195	180
3	200	195	?	195	195	175
mÃp mõ						
1	210	210	?	205	205	175
2	195	195	?	190	200	170
3	195	195	?	190	185	155
lÃp lÃɳ						
1	205	190	?	205	215	185
2	210	200	?	205	215	175
3	205	205	?	195	205	170

	First Syllable			Second Syllable		
	onset	2/3	end	onset	mid	end
gõl lÃ						
1				210	210	170
2	200	200	?	205	205	185
3	195	195	?	195	200	165
gÃt gõ						
1				210	215	185
2	210	210	?	195	205	160
3	200	200	?	190	190	150
gÃp gèp						
1	215	215	?	215	220	170
2	200	200	?	215	215	175
3	205	200	?	205	210	205
zÃp võl						
1				195	210	180
2	210	205	?	200	200	175
3	195	195	?	190	190	160
zÃ zõl						
1	205	205	?	205	205	180
2	200	200	?	205	205	185
3	195	195	?	195	195	180
bÃp bèɳ						
1				190	190	170
2	205	200	?	190	190	170
3	195	195	?	195	190	175
bÃp bèp						
1	210	210	?	205	205	170
2	200	200	?	200	205	165
3	205	200	?	190	190	185
mÃt dÃm						
1	200	205	?	205	205	170
2	205	200	?	195	200	175
3	195	195	?	185	185	165

	First Syllable			Second Syllable		
	onset	2/3	end	onset	mid	end
lũõt dõ						
1	210	205	?	205	215	165
2	200	205	?	200	200	180
3	200	200	?	195	200	170
lõn pÃu						
1				215	215	180
2	205	205	?	205	210	185
3	200	200	?	200	205	175
lÃt mÃu						
1				195	205	170
2	205	205	?	195	200	180
3	205	205	?	190	195	160
lÃk luÃl						
1				205	210	185
2	205	205	?	205	200	180
3	195	195	?	195	195	155
lÃk dõ						
1	215	205	?	200	205	175
2	190	190	?	195	200	170
3	195	190	?	190	190	180
dõɳ l3ɳ						
1	210	210	?	215	215	180
2	195	200	?	220	210	175
3	195	195	?	205	205	170
Total	11305	11240		9685	13485	11655
Ave.	201.8	200.7		201.7	204.3	176.5

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5. Drop + Curve

	First Syllable			Second Syllable		
	onset	2/3	end	onset	2/3	end
tɔ̃t bɛ̃						
1	205	205	?	200	180	195
2	200	210	?	200	155	170
3	200	200	?	195	155	175
dɑ̃p dɛ̃						
1				195	160	190
2	195	195	?	195	160	190
3	190	190	?	185	150	170
dɔ̃k zɑ̃						
1	205	205	?	190	140	170
2	195	195	?	190	145	155
3	190	190	?	185	130	130
tɛ̃t dɛ̃						
1	205	205	?	185	165	185
2	195	195	?	180	150	170
3	190	190	?	180	145	170
tʃɑ̃n zɑ̃						
1				200	170	160
2	200	200	?	185	155	155
3	190	190	?	190	150	180

	First Syllable			Second Syllable		
	onset	2/3	end	onset	2/3	end
mɛ̃t bɑ̃u						
1				180	165	170
2	195	195	?	175	150	170
3	190	190	?	175	150	180
mɛ̃t mɔ̃t						
1				180	150	175
2	195	195	?	200	155	185
3	190	190	?	180	150	170
pɑ̃k dɪ̃ɑn						
1				190	160	190
2	195	195	?	185	150	175
3	190	185	?	180	145	185
pɑ̃p dɑ̃ŋ						
1				195	165	185
2	195	185	?	185	165	185
3	195	195	?	175	150	185
bɑ̃ŋ ɜ̃ŋ						
1				190	145	200
2	190	190	?	185	155	185
3	190	190	?	185	150	175

	First Syllable			Second Syllable		
	onset	2/3	end	onset	2/3	end
dɑ̃l dɑ̃m						
1				195	150	180
2	185	185	?	185	155	180
3	190	190	?	185	150	180
zɑ̃ŋ vɛ̃						
1				190	155	170
2	195	185	?	180	145	160
3	190	190	?	185	150	150
vɑ̃n dɔ̃						
1	210	210	?	195	155	170
2	190	190	?	185	150	170
3	190	190	?	180	150	165
Total	5645	5820		7295	5975	6805
Ave.	188.1	194.0		187.0	153.2	174.4

6. Drop + Drop

	First Syllable			Second Syllable		
	onset	2/3	end	onset	2/3	end
bɑ̃k mɑ̃p						
1	225	225	?	210	215	?
2	220	220	?	210	215	?
3	220	220	?	215	215	?
bɑ̃l tʊ̃						
1	205	205	?	210	195	?
2	200	200	?	205	205	?
3	195	195	?	210	210	?
bɑ̃u dʊ̃ŋ						
1	205	205	?	220	215	?
2	205	205	?	210	210	?
3	200	200	?	205	205	?
bɑ̃n zɑ̃n						
1	210	210	?	220	220	?
2	205	205	?	215	215	?
3	205	205	?	210	195	?
bɑ̃n zɑ̃n						
1	205	205	?	215	205	?
2	190	190	?	210	190	?
3	195	195	?	205	185	?
dɑ̃l bɑ̃l						
1	205	205	?	205	195	?
2	205	205	?	205	180	?
3	200	200	?	205	195	?
dɑ̃l dɑ̃u						
1	210	210	?	210	200	?
2	195	195	?	210	210	?
3	185	185	?	205	195	?
dɑ̃l dɑ̃l						
1	210	210	?	205	205	?
2	205	205	?	205	205	?
3	200	200	?	200	200	?

	First Syllable			Second Syllable		
	onset	2/3	end	onset	2/3	end
dɔ̃k tɛ̃ŋ						
1	205	205	?	205	195	?
2	195	195	?	195	190	?
3	195	190	?	195	190	?
dɔ̃ŋ dɛ̃t						
1	210	210	?	205	205	?
2	205	205	?	210	210	?
3	200	200	?	205	205	?
dɔ̃ŋ vɛ̃t						
1	205	205	?	200	185	?
2	195	195	?	200	195	?
3	195	195	?	190	185	?
gɑ̃t tʊ̃						
1	215	200	?	210	205	?
2	205	195	?	205	200	?
3	200	195	?	195	190	?
hɑ̃p bɛ̃						
1	200	200	?	195	195	?
2	195	195	?	190	190	?
3	195	195	?	195	195	?
hɔ̃ zɑ̃k						
1				205	190	?
2	195	195	?	195	190	?
3	195	195	?	190	185	?
hɔ̃ vɛ̃						
1	175	185	?	215	210	?
2	210	205	?	210	200	?
3	205	200	?	205	205	?
hɑ̃n nɑ̃n						
1	220	220	?	215	195	?
2	205	205	?	215	205	?
3	195	195	?	205	205	?

	First Syllable			Second Syllable		
	onset	2/3	end	onset	2/3	end
hɔ̃ zɑ̃ŋ						
1	210	210	?	215	200	?
2	190	190	?	215	210	?
3	190	190	?	210	200	?
hɔ̃ dɛ̃l						
1	210	210	?	215	205	?
2	190	190	?	200	200	?
3	180	180	?	200	200	?
hɔ̃ŋ zɑ̃						
1				205	195	?
2	190	190	?	210	195	?
3	185	185	?	200	195	?
zɑ̃l zɑ̃t						
1	185	185	?	210	205	?
2	195	190	?	205	200	?
3	200	190	?	200	200	?
zʊ̃k vɔ̃ŋ						
1				210	195	?
2	200	200	?	200	200	?
3	200	200	?	200	200	?
dɑ̃u nɑ̃u						
1	195	195	?	215	215	?
2	195	195	?	195	200	?
3	195	190	?	195	185	?
dɛ̃t gɛ̃t						
1	205	205	?	200	195	?
2	200	190	?	200	190	?
3	195	195	?	200	185	?
gɛ̃l gɔ̃k						
1	200	200	?	200	200	?
2	200	200	?	195	190	?
3	185	185	?	195	190	?
Total	13810	13745		14760	14350	
Ave.	200.1	199.2		205.0	199.3	

In Table 2-B-1, the average f_0 values for each point of measurement which appeared at the end of each combination in Table 2-A, are arranged in six groups, a,b,c,d,e, and f. The first group 'a' presents six combinations having the level tone in the first syllable and the six different tones in the second syllable; and the second group 'b' presents six combinations having the rising tone in the first syllable and the six different tones in the second syllable. The four other groups, c,d,e, and f are also arranged in the same way. These rearrangements were made to facilitate the analysis of the variation of individual tones in the first syllable, and also that of the pattern of six tone contrast in the second syllable.

Figure 2-B-1 presents graphically the same data shown in Table 2-B-1. The six parts of Table 2-B-1, a through f, correspond to the six schematic representations, a through f of Figure 2-B-1 respectively. The duration of the syllable is approximately the same as the average duration of the actual utterances spoken by our principal informant as they are seen on the spectrograms, and the f_0 values of the pitch contours have been plotted on a logarithmic scale so that these figures might approximate perceptual reality. The thin lines between the first and second syllables have been drawn to show the respective tonal environments. The duration of the transition between two syllables in

Figures 2-B-1 is about twice as long as that of the actual utterances. The thin lines were drawn in this way to facilitate the reading of the respective environments of the tones.

Table 2-B-2 displays the same data presented in Table 2-B-1 except that they have been rearranged to facilitate the analysis of the variation of each tone in the second syllable position. This display also facilitates the analysis of the variation in the pattern of the six tone contrast in the first syllable position. Tone combinations are rearranged into six groups according to the tone in the second syllable. The first group in Table 2-B-2 consists of the first combinations of the six groups in Table 2-B-1, in which the second syllable bears the level tone, and the second group in Table 2-B-2 consists of the second combinations of the six groups in Table 2-B-1, in which the second syllable bears the rising tone, and so on. The measurements of a combination in Table 2-B-2 are exact duplicates of the corresponding combination in Table 2-B-1.

Figure 2-B-2 presents graphically the same measurements presented in Table 2-B-2. The six figures, a through f in Figure 2-B-2 correspond to the six parts, a through f in Table 2-B-2 respectively. These figures have been drawn in the same way as described for Figure 2-B-1 and should be read accordingly.

Table 2-B-1

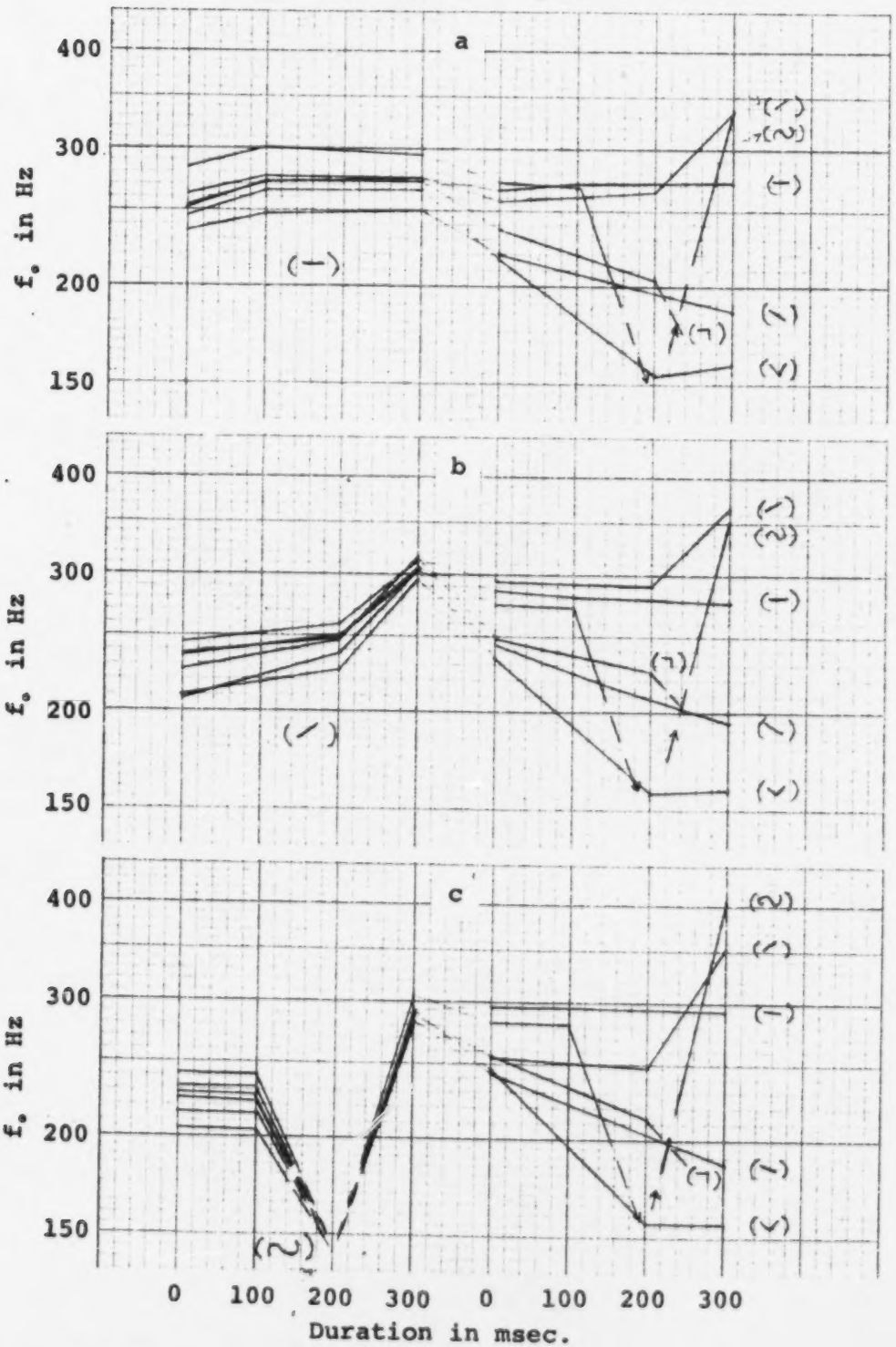
Average F_0 of the Tones in Two-Syllable Utterances
(Tone in the First Syllable Constant)

	Combination	No. of Occurences	First Syllable onset	mid	2/3	end	Second Syllable onset	mid	2/3	end
a.	level + level	75	253	271		273	267	271		272
	level + rising	63	261	276		273	258		264	336
	level + broken	72	284	301		295	272		?	373
	level + falling	72	236	249		250	220	201		186
	level + curve	51	246	267		267	219		154	158
	level + drop	39	251	272		272	238		203	?
b.										
	rising + level	54	235		250	305	286	281		277
	rising + rising	72	245		259	311	294		290	367
	rising + broken	24	237		249	302	274		?	361
	rising + falling	57	210		226	295	243	215		194
	rising + curve	30	209		238	301	233		157	158
	rising + drop	27	227		248	314	249		226	?
c.										
	broken + level	42	232		?	292	292	295		292
	broken + rising	21	229		?	282	253		247	351
	broken + broken	42	241		?	305	282		?	406
	broken + falling	42	205		?	282	242	212		186
	broken + curve	6	223		?	290	243		157	157
	broken + drop	33	216		?	287	255		213	?

d. Combination	No. of Occurences	First Syllable onset	mid	2/3	end	Second Syllable onset	mid	2/3	end
falling + level	63	223	224		221	250	267		266
falling + rising	63	208	207		202	208		221	305
falling + broken	42	220	215		214	217		?	352
falling + falling	48	206	208		202	203	200		174
falling + curve	18	207	215		211	199		156	162
falling + drop	57	210	214		208	207		206	?
e.									
curve + level	54	194		167	161	225	260		262
curve + rising	30	190		156	156	190		218	309
curve + broken	18	189		159	160	193		?	342
curve + falling	33	183		168	160	193	207		187
curve + curve	36	184		157	166	184		151	178
curve + drop	48	186		166	166	194		196	?
f.									
drop + level	60	220		216	?	249	274		273
drop + rising	45	212		211	?	219		247	347
drop + broken	63	214		209	?	209		?	338
drop + falling	66	202		201	?	202	204		177
drop + curve	39	188		194	?	187		153	174
drop + drop	72	200		199	?	205		199	?

Figure 2-B-1

Schematic Representations of Two-Tone Combinations
(Tone in the First Syllable Constant)



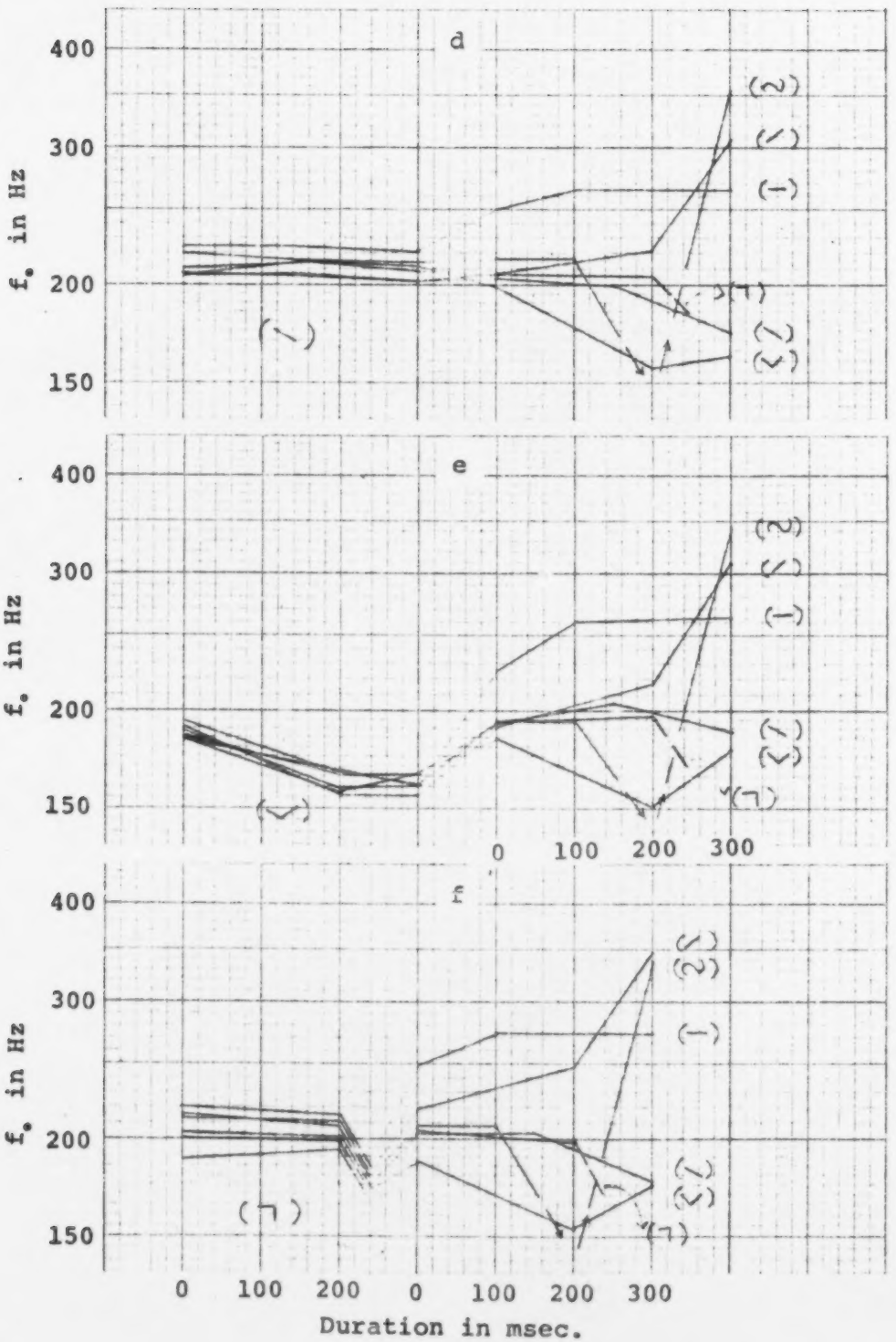

d
e
f
400
300
200
150
f₀ in Hz
0
100
200
300
Duration in msec.

Table 2-B-2

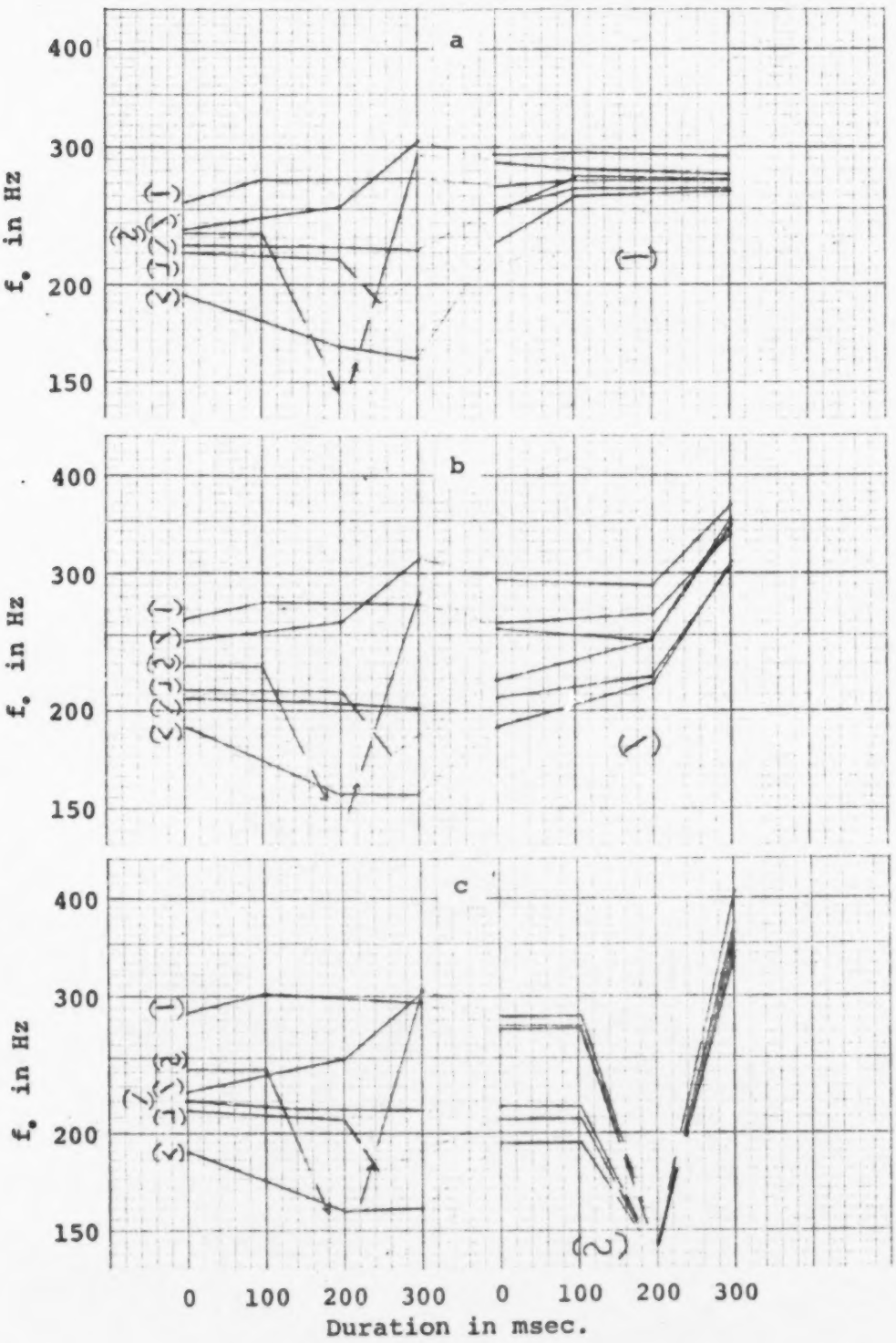
Average F_0 of the Tones in Two-Syllable Utterances
(Tone in the Second Syllable Constant)

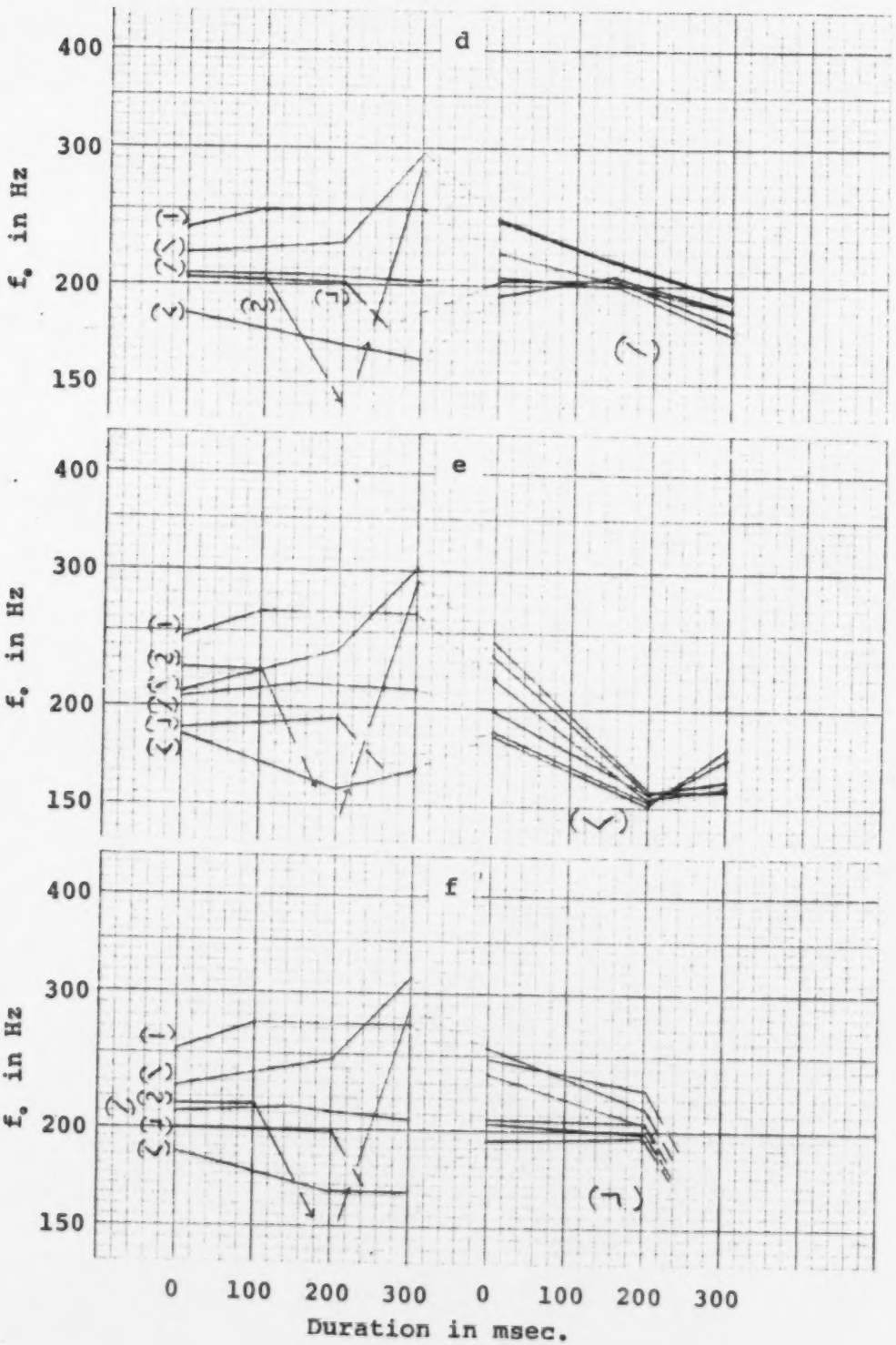
	Combination	No. of Occurences	First Syllable onset	mid	2/3	end	Second Syllable onset	mid	2/3	end
a.	level + level	75	253	271		273	267	271		272
	rising + level	54	235		250	305	286	281		277
	broken + level	42	232		?	292	292	295		292
	falling + level	63	223	224		221	250	267		266
	curve + level	54	194		167	161	225	260		262
	drop + level	60	220		216	?	249	274		273
b.										
	level + rising	63	261	276		273	258		264	336
	rising + rising	72	245		259	311	294		290	367
	broken + rising	21	229		?	282	253		247	351
	falling + rising	63	208	207		202	208		221	305
	curve + rising	30	190		156	156	190		218	309
	drop + rising	45	212		211	?	219		247	347
c.										
	level + broken	72	284	301		295	272		?	373
	rising + broken	24	237		249	302	274		?	361
	broken + broken	42	241		?	305	282		?	206
	falling + broken	42	220	215		214	217		?	352
	curve + broken	18	189		159	160	193		?	342
	drop + broken	63	214		209	?	209		?	338

	Combination	No. of Occurences	First Syllable onset	mid	2/3	end	Second Syllable onset	mid	2/3	end
d.	level + falling	72	236	249		250	220	201		186
	rising + falling	57	210		226	295	243	215		194
	broken + falling	42	205		?	282	242	212		186
	falling + falling	48	206	208		202	203	200		174
	curve + falling	33	183		168	160	193	207		187
	drop + falling	66	212		201	?	202	204		177
e.										
	level + curve	51	246	267		267	219		154	158
	rising + curve	30	209		238	301	233		157	158
	broken + curve	6	223		?	290	243		157	157
	falling + curve	18	207	215		211	199		156	162
	curve + curve	36	184		157	166	184		151	178
	drop + curve	39	188		194	?	187		153	174
f.										
	level + drop	39	251	272		272	238		203	?
	rising + drop	27	227		248	314	249		226	?
	broken + drop	33	216		?	287	255		213	?
	falling + drop	57	210	214		208	207		206	?
	curve + drop	48	186		166	166	194		196	?
	drop + drop	72	200		199	?	205		199	?

Figure 2-B-2

Schematic Representations of Two-Tone Combinations
(Tone in the Second Syllable Constant)




d
e
f
400
300
200
150
f_o in Hz
0
100
200
300
Duration in msec.

In the following, the data are analyzed from two different viewpoints: (1) how individual tones are affected by their environments and, (2) how the pattern contrasting the six tones varies depending upon the environment. The former involves the analysis of phonetic variation of individual phonemic tones and the latter the variation of the system of contrast of the six tones.

A. Variation of Individual Tones

In this section we will examine the variation of individual tones in terms of (1) the characteristic pitch contour of the tones and, (2) the overall pitch height of the tones. We will discuss first the variation of the tones in their pitch contour.

One might get a general impression from Figures 2-B-1 and 2-B-2 that the overall pitch of a tone varies to a great extent but the basic pitch contours of the six tones as described in the preceding chapter for one-syllable utterances are modified to a much less extent. This seems to be true particularly with the level, rising, broken and drop tones. Of course, we are aware that the variation of the rising, broken, and drop tones in the second syllable position as shown in Figures 2-B-2-b, 2-B-2-c, and 2-B-2-f is not simply a variation in overall pitch. For example, in Figure 2-B-2-b, the f_0 actually decreases in the first two-

thirds of some of the contours, in others, it rises. In other words, the contours themselves differ. We will, however, exclude the variation of these tones in these particular environments from the discussion of the variation of tone contour, since this is the type of variation which does not result in an overlap in contour between different tones. In the following we will discuss only those kinds of variation which result in an overlap or near-overlap between different tones.

We notice in the first syllable of Figure 2-B-1-d that there is very little pitch fall in the falling tone in this environment and the contour is quite similar to that of the level tone. The contour of these variants are different from that of the level tone only in the initial portion of the contour, the variants of the level tone having slight pitch rise at the beginning of the contour. But as we have already noted, this initial rise in the level tone is not consistent in the speech of other informants, and even in the principal informant it has been observed that there are a number of cases in which the initial rise does not occur. In consequence, this case of overlap in pitch contour between the level and falling tones suggests that the more consistent distinctive feature differentiating these two tones is the relative height of the overall pitch, not the shape of the contour.

For the curve tone in one-syllable utterances, a considerable pitch rise, about 4.7 semitones, has been observed in the last third of the syllable nucleus. We notice, however, that in the first syllable of Figure 2-B-1-e, there is hardly any pitch rise in the last one-third of the curve tone. This phenomenon has been observed also in a male informant's speech. Even in the other informant's speech, in which the final rise is observed, the amount of rise is much reduced in this environment. For example, in the speech of another female speaker, the final rise in monosyllabic utterances is 9.8 semitones and the rise in the same environment as the first syllable in Figure 2-B-1-e has been reduced to 5.8 semitones. What is common in the speech of all the informants is the location of the point at which the pitch fall from the onset turns to another phase, that is, level or slight rise. There seems to be a strong indication that the final pitch rise at the last one-third is less important than the location of the turning point mentioned above. In certain cases the location of the turning point does not seem to be crucial. Examine the pitch contour of the curve tone before the falling tone as shown in the first syllable of Figure 2-B-1-e or the first syllable of Figure 2-B-2-d. This particular variant of the curve tone does not show any reduction in the pitch fall at the point two-thirds of the entire

duration of the pitch contour; instead the pitch fall is gradual without any change to the end of the contour. The resultive contour is hardly different from the pitch contour of the falling tone in one syllable utterances (cf. Figure 1).

Now how does such a variation of the curve tone contrast with the real falling tone? The answer is immediately clear if we compare the pitch contours of the falling and curve tones in the first syllable of Figure 2-B-2-d. The overall pitch of the contour of the falling tone is much higher than that of the curve tone in this identical environment, higher by 2.1 semitones at the onset and 4.4 semitones at the end-point. Here, both the falling and curve tones have undergone a considerable modification in their pitch contour but the manner and extent of the modification are such that the basic pattern of contrast between them is kept unaffected. We will discuss more about the nature of such variation later in this paper.

Let's focus our attention on the overall pitch height of each tone in different environments. In Table 3-A, which is derived from Table 2-B-1, the measurements of the highest and lowest variants of each tone in the first syllable position are tabulated. In this table, the tone labels in the leftmost column are followed by information about the highest and lowest variants of the respective

tones. In the left half of this table, the environment of the highest variants of the tones and the f_0 measurements of these variants are given. In the right half of the table, the same kind of information about the lowest variants of the tones is presented. For example, the row beginning with the label 'level' shows that the highest variant of the level tone in the first syllable position occurs before the broken tone as indicated by '¯~' and the f_0 measurements at three different points are 284-301-295. The second half of this row shows that the lowest variant occurs before the falling tone (i.e., ¯`) and the f_0 measurements are 236-249-250. In a similar manner the variations in pitch height of other tones are presented.

In Table 3-B, which is derived from Table 2-B-2, the environments of the highest and lowest variants of each tone in the second syllable position and the f_0 measurements of these variants are presented. This table should be read in the same way as Table 3-A except that the tones given in the leftmost column occur in the second syllable position.

For an easier comparison of the highest and lowest variants of each tone in different syllable positions, the variants of each tone have been schematically presented on semi-logarithmic graph paper as in Figures 3-A and 3-B. The six figures on the left hand side of pages 50 and 51 are derived from the information in Table 3-A, thus representing

Table 3-A

The Highest and Lowest Variants of the Six Tones in the First Syllable Position (in Hz)

	Highest Variant					Lowest Variant				
Tone	Environ	Onset	Mid f_0	2/3	End	Environ	Onset	Mid f_0	2/3	End
level	¯+¯	284	301		295	¯+˴	236	249		250
rising	ˊ+ˊ	245		259	311	ˊ+˴	210		226	295
broken	˜+¯	232		?	292	˜+˴	205		?	282
falling	˴+¯	223	224		221	˴+˴	206	208		202
curve	ˇ+¯	194		167	161	ˇ+ˇ	184		157	166
drop	˥+¯	220		216	?	˥+ˇ	188		194	?

Table 3-B

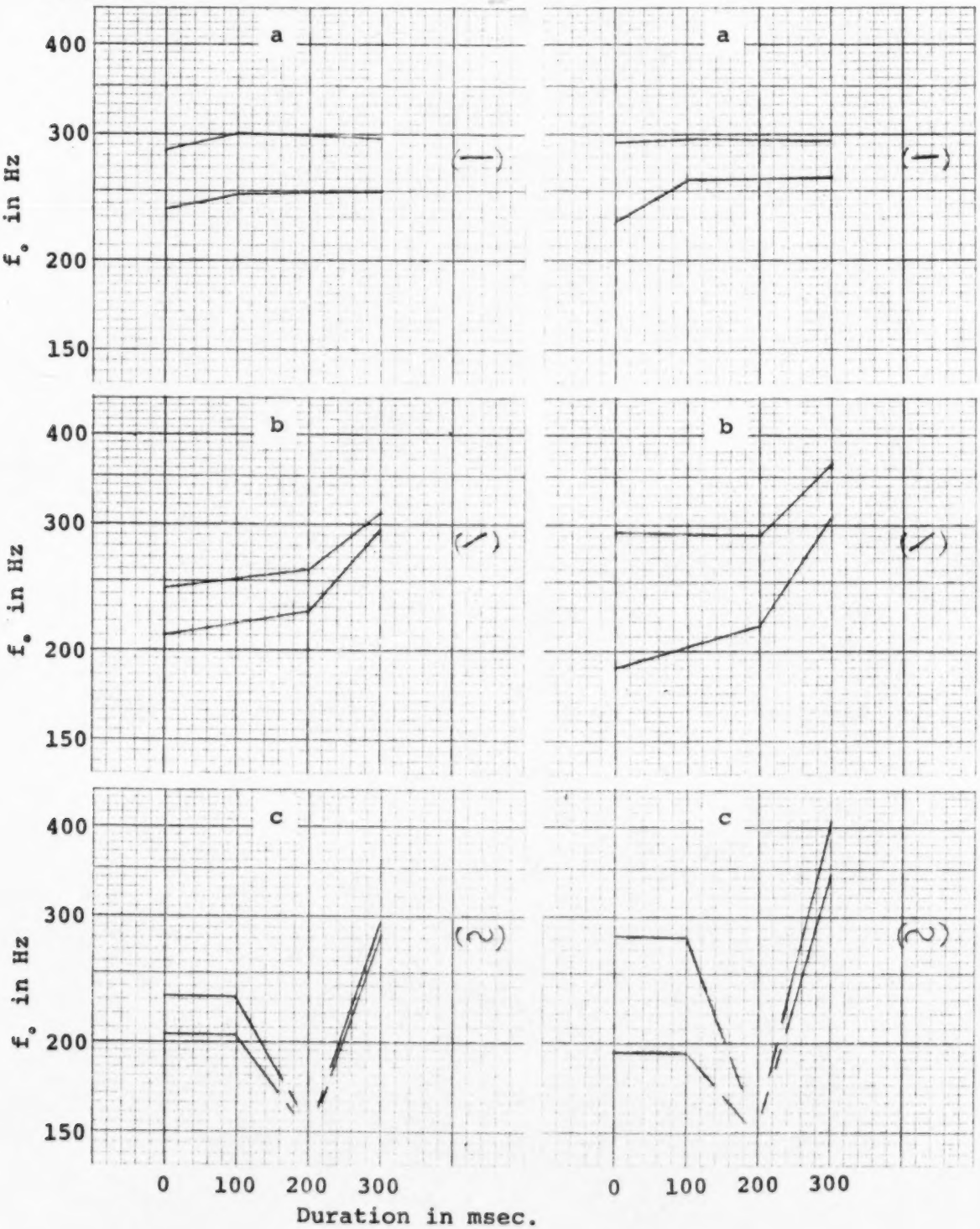
The Highest and Lowest Variants of the Six Tones in the Second Syllable Position

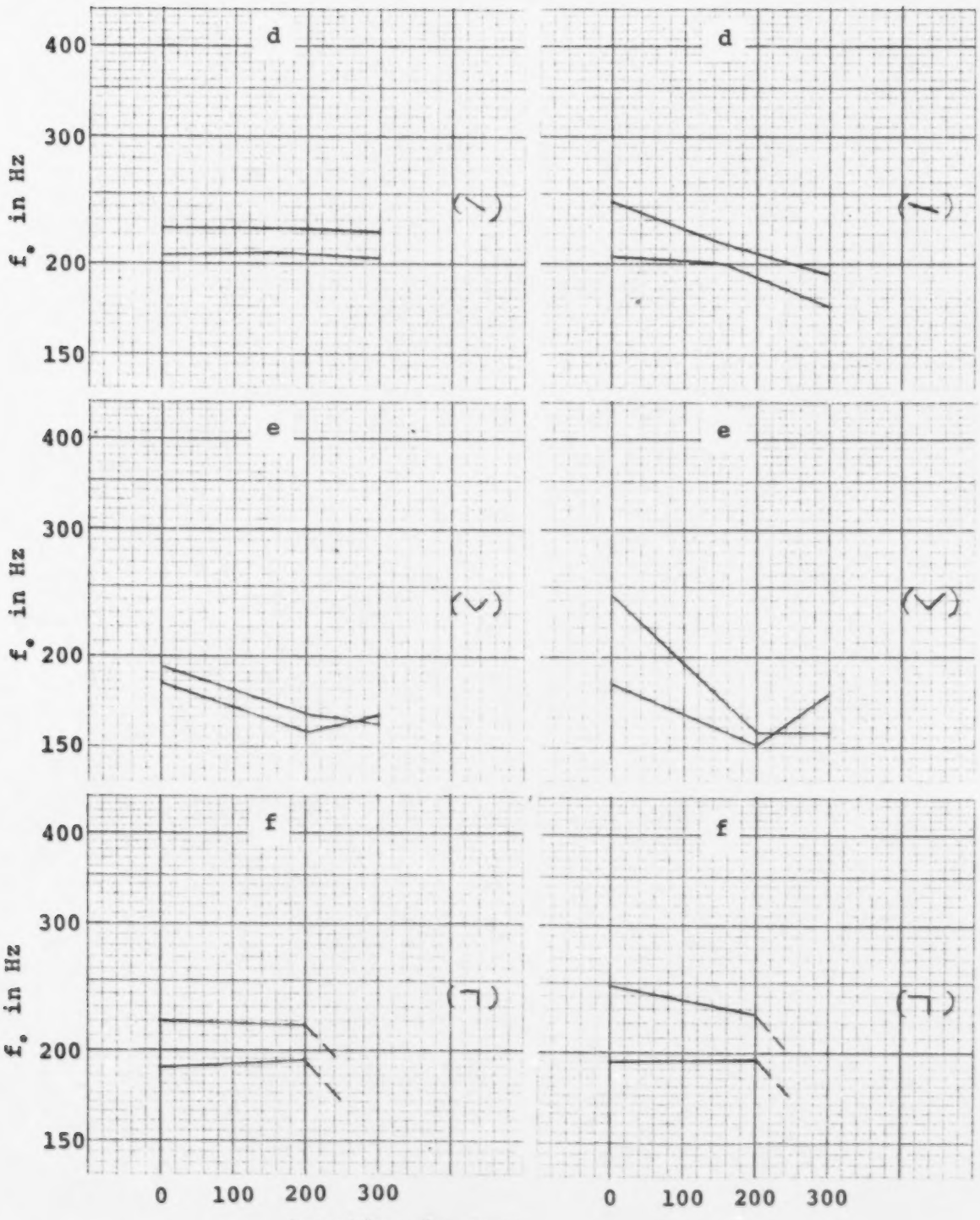
(in Hz)

	Highest Variant					Lowest Variant				
Tone	Environ	Onset	Mid f_0	2/3	End	Environ	Onset	Mid f_0	2/3	End
level	˜+¯	292	295		292	˅+¯	225	260		262
rising	ˊ+ˊ	294		290	367	˅+ˋ	190		218	309
broken	¯+˜	282		?	406	˅+˜	193		?	342
falling	ˊ+ˋ	243	215		194	ˋ+ˋ	203	200		174
curve	˜+˅	243		157	157	˅+˅	184		151	178
drop	ˊ+˥	249		226	?	˅+˥	194		196	?

Figure 3-A
The Highest and Lowest Variants of the Tones in the First Syllable Position

Figure 3-B
The Highest and Lowest Variants of the Tones in the Second Syllable Position




d
d
e
e
f
f
400
300
200
150
f_0 in Hz
(ヽ)
(ヽ)
(ヽ)
(ヽ)
(ㄱ)
(ㄱ)
0
100
200
300
Duration in msec.

the highest and lowest variants of the tones in the first syllable position. On the other hand, the six figures on the right-hand side of these two pages are based on Table 3-B, thus representing the highest and lowest variants of the tones in the second syllable position.

In the figures above, two general observations can be made, (1) the difference between the highest and lowest variants of each tone is greater in the second syllable position than in the first syllable position, and (2) the degree of variation is not the same at onset and end-point of a tone and is usually greater at the onset-point than at the end-point.

The first observation noted above is readily seen by comparing the distances between the corresponding points of the highest and lowest variants in the left-hand side figures with those distances in the matching right-hand side figures. For example, take Figures 3-A-b and 3-B-b which show the highest and lowest variants of the rising tone in the first and second syllable positions. As shown in Figure 3-B-b, the differences between the highest and lowest variants at the onset and end-point are 104 Hz (9 semitones) and 58 Hz (3.1 semitones) respectively. These differences are roughly three times as great as the corresponding differences in Figures 3-A-b which are 35 Hz (2.8 semitones) at the onset and 16 Hz (0.9 semitone) at the end-point. With the level

tone, this tendency is not manifested; that is, the two variants in Figure 3-B-a are closer to each other than the two variants in Figure 3-A-a. However, we will not take this case as implying that the level tone is exceptional in this respect. In our second female informant, exactly the same phenomenon as observed for other tones has been observed with the level tone.

The exact cause of such phenomena is unknown to us, but one thing is clear, and that is, in two-syllable utterances the progressive effect, which is defined as the effect of a tone on another in the immediately following syllable, is greater than the regressive effect which is the effect in the opposite direction. A tone is realized as an elevated or lowered variant in anticipation of a following high or low tone, and the tone in the second syllable, in turn, is raised or lowered depending upon the relative height of the preceding tone. Thus the effect is reciprocal and the effect of the tone in the first syllable on the second syllable is greater than that of the second syllable on the preceding one.

Our second observation can be seen in Figures 3-A and 3-B; when a tone is raised or lowered due to its tonal environment the amount of variation is greater at the onset than the end-point. This phenomenon is evident in both the first and second syllable positions and seems to be more prominent with the tones which have extremely high or low

final target points, such as the broken and curve tones. With other informants, this phenomenon is not as consistent or prominent as the first observation. However, this could be taken as an indication that the end-point of the tones is more stable and resistent to the environmental influence.

In addition to the observations discussed above, it should be noted that the curves for the highest and lowest variants do not cross each other, with the exception of the curve tone. In other words, both the onset and end-points of the highest variant of a tone are higher than those of the lowest variant of the same tone. In general, this holds true with the other intermediate variants of the tone; that is, a variant with a higher onset than another variant also has a higher end-point than the other variant. This is the very reason why the variants of a tone keep their basic contour despite their distribution within a large range of pitch. This will be discussed further in the following section.

B. Variation of the Pattern of Six Tone Contrast

In the following section, we will discuss the manner in which the six different tones contrast with each other. This information is found in the second syllables of Figure 2-B-1 and the first syllables in Figure 2-B-2. At first glance, all the pictures of the six tone contrast look very similar to

each other and also look like duplicates of Figure 1 which shows the pattern of the six tone contrast in one-syllable utterances. However, a closer look will reveal some interesting phonemena and systematic variations behind the similarity, some of which will be described below.

As was mentioned when we described the pitch contours of the six tones in one-syllable utterances, the pitch height of some tones (e.g., rising tone) are higher than those of others (e.g., falling tone). We pointed out that at the onset the difference between the f_0 values for the highest and lowest tones, (the level and curve tones respectively), is 5.1 semitones; and at the end-point the difference between the highest and lowest tones (broken and falling tones respectively) is 19.9 semitones. To check how these ranges at the onset and end-points of the six tones vary depending on different environments, Table 4 has been prepared.

The left half of Table 4 presents the differences between the highest and lowest tones at the onset and end-points in the first syllable position. This part of the table is derived from Table 2-B-2. For example, the leftmost column in the left half of Table 4 indicates the environment of the occurrence of the six tones, each of the six rows in this table correspond to the six parts of Table 2-B-2. In the first part 'a' of Table 2-B-2, the f_0 of the highest onset among those of the six tones, that of the level tone,

is 253 Hz. and the lowest onset, that of the curve tone, is 194 Hz. The difference between these two points, which is 59 Hz. or 5.1 semitones, is found in the first row of the second column in Table 4. The difference, 144 Hz. or 14.9 semitones, between the highest and lowest end-points, 305 Hz. of the rising tone and 161 Hz. of the curve tone respectively, is given in the first row of the third column in Table 4. All the other differences in the left half of Table 4 have been obtained in the same way. The right half of Table 4 is derived from Table 2-B-1 and contains the same kind of information as the left half except that the six tones occur in the second syllable position.

The second column of the left half of Table 4 shows that the pitch range of the onset of the six tones in the first syllable varies depending on the environments from 4.8 to 8.4 semitones, the average being 5.9 semitones. This average is slightly greater than the range of 5.1 semitones obtained from the one-syllable utterances. On the other hand, the second column of the right half of Table 4 shows that the same range varies from 3.4 to 5.5 semitones in the second syllable. The average, 4.2 semitones, is smaller by 1.7 semitones than the average of the first syllable. In another female informant's speech, the pitch range of the six tones in the first syllable is 5.0 semitones and that in the second syllable is 4.4 semitones. The difference between these two ranges of 0.6 semitones, considerably smaller than

Table 4

Difference in F_0 Between the Highest and Lowest Onset and End-Points of the Six Tones in Various Environments

(in Hz. and Semitones)

	1st Syllable			2nd Syllable	
Environ	Difference at Onset	Difference at End	Environ	Difference at Onset	Difference at End
_ level	59 (5.1)	144 (14.9)	level _	53 (4.0)	215 (22.7)
_ rising	71 (6.2)	155 (16.6)	rising _	61 (4.4)	209 @22.0)
_ broken	95 (8.4)	145 (15.1)	broken _	50 (3.4)	249 (26.4)
_ falling	53 (4.8)	135 (14.1)	falling _	51 (4.3)	190 (19.5)
_ curve	62 (5.6)	135 (13.6)	curve _	41 (3.7)	164 (15.4)
_ drop	65 (5.8)	148 (14.9)	drop _	62 (5.5)	173 (16.6)
Average	(5.9)	(14.8)	Average	(4.2)	(20.4)

the 1.7 semitones of the principal informant. Our speculation about the reason for the smaller range at the onset of the six tones in the second syllable is that the target pitch of the end-point of the tone in the first syllable in effect regulates the immediately adjacent onset f_0 value for the following syllable; the onset of a tone in the first syllable lacks such regulating force.

The variation of the pitch ranges of the end f_0 value for the six tones in different syllable positions is much greater (cf. the third columns of each half of Table 4). The difference in the average ranges between the first and second syllables is as great as 5.6 semitones (i.e., 20.4 - 14.8 = 5.6). The much smaller values in the third column of the left half of Table 4 in comparison to those in the corresponding column in the right half indicate that the onset of the second syllable pulls up or down the extremely high or low end-points of the six tones in the first syllable while there is no such force immediately after the end-points of the six tones in the second syllable.

Is there any regularity in the order of pitch height of the onset and end-points of the six tones? We have not observed any strict consistency in this order (cf. the second syllables of Figure 2-B-1 and the first syllables of Figure 2-B-2) Earlier in this paper, we divided the six tones into two groups, a group of high tones with higher overall pitch and

another of low tones with lower overall pitch. Now the only generalization we can make about the order mentioned above is that the pitches of the onset and end-points of the high tones are higher in general than those of the low tones. The order of the pitch heights of the six tones observed in the analysis of one-syllable utterances is not strictly maintained in various environments.

Another thing to be noted is the unusual height of the pitch ranges of the onset-points of the six tones after level, rising, and broken tones (cf. the second syllables of Figures 2-B-1-a through c). The average of the onset f_0 values for the six tones in these environments is higher by approximately three semitones than that after the other remaining tones. This difference could be taken roughly as the magnitude of the effect of these three high tones on the tones in the second syllable. In all three cases, the onset f_0 values of the six tones are raised by the same amount. This uniform effect of an environment on another is the very reason why the contrast of the six tones is maintained within an environment despite drastic modifications in the phonetic shape of the individual tones caused by the environment.

Conclusion

In this report, we have examined the nature of phonetic variation of Vietnamese tones in two-syllable utterances. All the data provided by the informants have been analyzed by the acoustic phonetic method. Our observations are summarized as follows:

1. The overall pitch height of a tone varies considerably depending upon its tonal environment. The degree of variation depends upon the magnitude of the influencing force, this force being a function of the difference in pitch between the influencing and influenced points. Thus a tone is realized as a high variant in an immediate environment of a high tone (i.e., the level, rising, or broken tone) and as a low variant in an immediate environment of a low tone (i.e., the falling, curve, or drop tone). The degree of variation in the pitch height also depends upon the syllable position. The variation is considerably greater in the second syllable position than the first syllable position. We take this fact as indicating that the progressive effect is greater than the regressive effect.

2. When the onset of a variant of a tone in a given syllable position is higher than that of another variant of the same tone in the same given syllable position, then the end-point of the former is also higher than that of

the latter. This is the very factor that keeps the basic contour of each tone relatively constant in a given syllable position within two-syllable utterances.

3. The variation in the pitch height of a tone is of an asymmetric nature in the sense that, even though the direction of the movement of both onset and end-point of a tone is the same, the absolute amount of variation of the onset of the tone in a given syllable position is not exactly the same as that of the end-point. Usually, the degree of variation is greater at the onset than the end-point, which seems to suggest the relatively greater stability of the end-point or the greater tendency for the end-point target pitch of the tones to be reached.

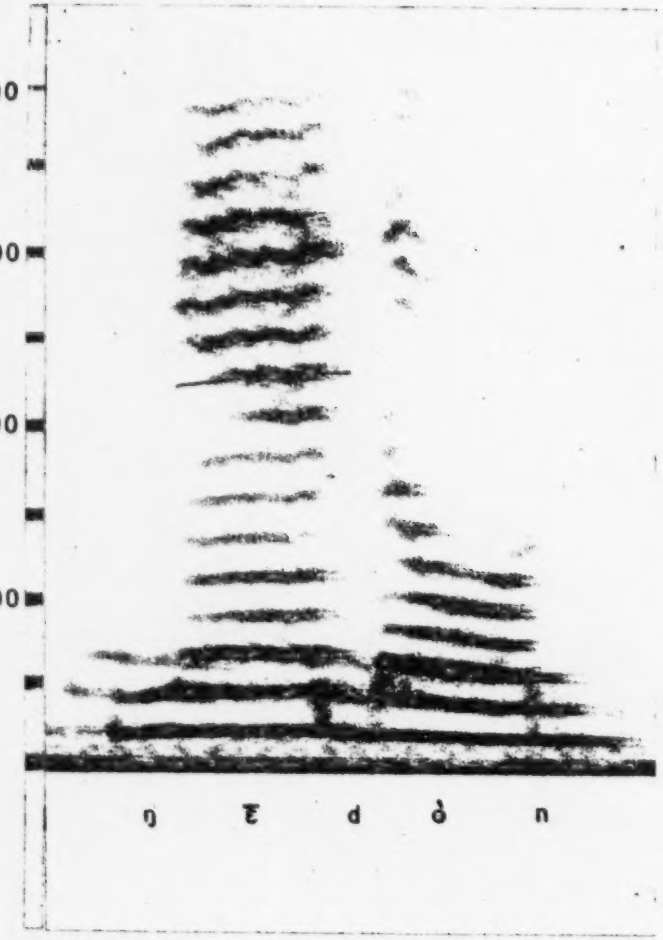
4. Our analysis of two-syllable utterances reveals two interesting phenomena about the falling and curve tones, which were not observed in the analysis of one-syllable utterances. The first is that the most consistent distinctive cue differentiating the level and falling tones is the difference in overall pitch height rather than the falling contour of the falling tone. The second is that the pitch rise at the end of the curve tone is not a very crucial cue of this tone in non-final syllable position. The curve tone in this environment is differentiated from the falling tone primarily by the lower pitch height plus the location of the lowest-pitched point of the curve tone.

5. Such variation of the individual tones as described above, however, does not affect the pattern of the six tone contrast in a given environment. A tone in a given syllable position affects the six tones in the other syllable position in a parallel manner. For example, if the extremely high end-point of a rising tone in the first syllable position pulls up the low onset of the falling tone in the second syllable position, then it would also pull up the onset of the other tones. **Because of this phenomenon together with the one mentioned in (2) above, the chance of an overlap between two tones in an identical environment does not increase.**

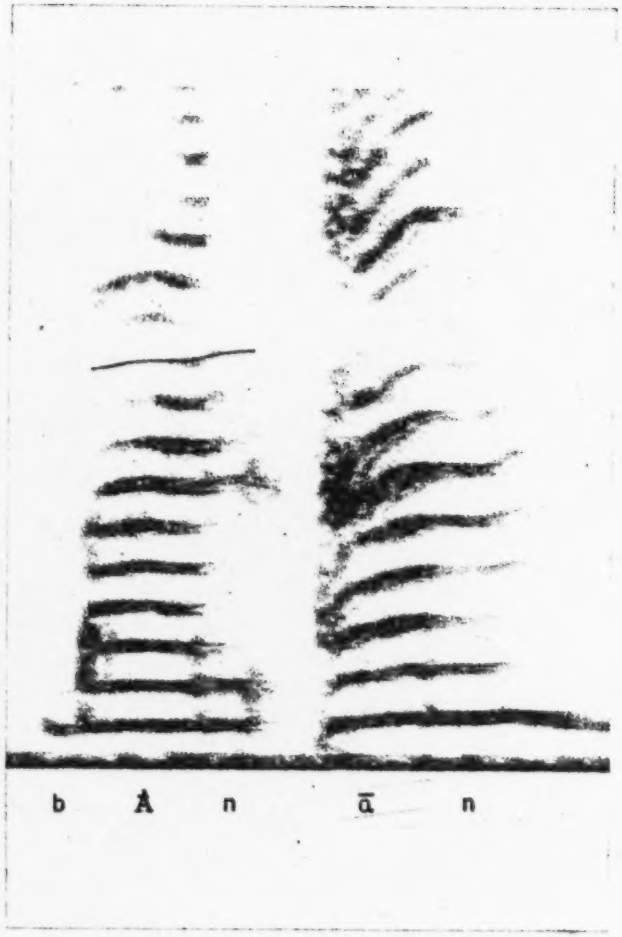
We like to show an interesting case which will make clear some points that we have described in this paper. In (5) above, we mentioned that the phonetic variation of the six tones never leads to a phonetic overlap between any two tones in an identical environment. However, this does not rule out the possibility of an overlap between two tones in two different environments. Indeed we have found a case of such an overlap in the speech of our principal informant. This case involves two two-syllable utterances, the spectrograms of which follow.

On Spectrograms 1 and 2, the tones in the first syllable position are different, but the overall pitch height and the

Spectrogram 1



Spectrogram 2



contour of these tones are hardly distinguishable. The first syllable of /ŋɛ̄ dòn/ 'to hear a rumor' in Spectrogram 1 is in level tone. Even though the contour of this level tone is level, the overall pitch height is unusually low for level tone. This particular level tone has been pulled down by the falling tone in the second syllable which has very low overall pitch height. Furthermore, this utterance token happens to be the last among the four repetitions of the test utterance, and the intonation effect seems to contribute to a further lowering of the overall pitch height of this token. However, the two tones in this utterance were unambiguously and correctly identified by native ear when this utterance was spoken in isolation. On the other hand, the first syllable of /bÅn ān/ 'dining table' in Spectrogram 2 is in the falling tone. But notice that the contour of this falling tone does not show any falling slope at all. (We already described such modification of the falling tone in the first syllable position as this particular case shows). Furthermore, the overall pitch height of the falling tone in Spectrogram 2 is even slightly higher than the level tone in Spectrogram 1. This falling tone has been considerably pulled up by the level tone in the second syllable position. In spite of the modification of the falling tone in its contour and overall pitch height, this utterance is correctly perceived by native speakers when

the two syllables in this utterance are spoken together.

In the above, we showed a case where two different tones overlap physically but still keep their perceptual identities. This fact provides further straight-forward evidence for some assumptions made about linguistic phenomena. First, the pitch levels in tone languages conventionally indicated by the numerals such as 1, 2, 3, etc. are not directly associated with any absolute f_0 values when they are applied to multisyllabic utterances. The two different tones in the first syllable position of Spectrograms 1 and 2 should be represented phonemically in terms of different levels in spite of the complete overlap in f_0. Second, this case also shows that if the variation, no matter how great it is, is not intended by the speaker but conditioned by the environment, then it does not lead to a confusion in the perception of the uttered tones if the conditioning environment is present. In our example above, the overlap is a result of an unusually great variation of the two tones involved but this physical overlap does not affect the perception of these two tones. In the absence of the second syllables, there is no way to distinguish these two utterances. Such an overlap is a purely accidental phenomenon.

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13. ABSTRACT

This study describes the phonetic variation of the six tones in two-syllable utterances of Vietnamese. The findings are summarized as follows:

1. The overall pitch height of a tone varies considerably depending upon its immediate tonal environment and also its syllable position. In a given syllable position, a variant of a tone adjacent to a high tone is higher than another variant adjacent to a low tone, and the phonetic variation of the tones is greater in the second syllable position than the first syllable position.

2. There is a tendency for any two variants of a tone in a given syllable position not to cross each other. This is a factor that keeps the basic contour of each tone relatively constant.

3. The range of variation of a tone is greater at the onset than at the end-point.

4. Our analysis of two-syllable utterances suggests that the overall pitch height is a more consistant cue than the contour for the differentiation of level tone from the falling tone.

5. In spite of all the intertonal influences, the pattern of the six tone contrast is unaffected in a given environment, due to the uniform effect which the environment excerts on the six tones.

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